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## THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

### THE AMERICAN NEGRO[1]

UNDER the comprehensive title chosen, it is my intention to discuss a single problem fundamental to studies of the colored population of the United States: the physical constitution of the American negro.

Students of the negro are aware of the lack of knowledge concerning this problem. Careful determination of the racial elements of the individual or group has been carried out in exceptional cases by relatively few investigators. A number of researches, economic, social, medical, have been completed or are now in progress, the results of which may be directly influenced by the factor of racial constitution, and this factor is generally unknown. The literature of the American negro abounds in contradictory claims concerning his native ability, his endurance of city life, resistance to disease, etc. Throughout the literature the environmental factors are usually recognized, the constitutional element commonly neglected, and to this circumstance some of the opposing results may be attributed.

The colored hybrids and pure-blood negroes are generally dealt with as a biological unit, when in fact the negroid population of the United States is composed of many different types. The hybrid is distinguished biologically from the white and from the negro, but society tries to make him a negro; and as a negro he enters into various records which are used as sources for study. Under such circumstances the conclusions of a research not only fail to convince but often add further complications to the question. Negro problems of importance in their relation to all elements of the population are undertaken without consideration of the racial mixtures of the groups used in the study.

Attempts to differentiate pure negroes and hybrids present many difficulties and it is recognized that the criteria used are inadequate. Further separation of the hybrids into the subgroups resulting from successive intermixtures with whites or blacks offers greater difficulties and permits less definite conclusions.

[1] Address by the retiring vice-president for Section H, American Association for the Advancement of Science, at a joint session with the American Anthropological Association, New York, December 29, 1928.

Davenport and Steggerda have separated two groups, "blacks" and hybrids or "browns" as they designate the mixtures. Herskovitz has recognized subgroups of the hybrids. While urging the necessity of differentiating subgroups (for which a satisfactory method is yet to be found) the purpose of this paper will be served by the use of the terms "blacks" for full-blood negroes and "browns" for the hybrids.

The following questions which are under discussion and are familiar to anthropologists as well as sociologists are offered in illustration of my contention that the solution of problems of the American negro rests in large measure upon knowledge of his constitution.

A matter which has attracted much attention and upon which there is now an extensive literature is the migration northward of the colored man. The movement from southern farms to northern cities has been active since 1910. It is a phenomenon of great economic significance from several standpoints—the substitution of white by negro labor, the reaction to limitation of immigration, the adaptability of the colored man in industry, etc. It is a matter also of biological interest. The question has arisen: "Can the colored man live in the north?" The answer is complicated by many factors: the sort of occupation; residence, whether rural or urban; sanitation of home and working conditions; the previous health of the migrant, etc. In attempting to answer the question it seems to me obvious that the first operation demanded is an analysis of the groups of immigrants in terms of racial constitution. Are both blacks and browns entering northern states? If so, what is the ratio of blacks to browns? If the blacks are so few that they can be regarded as negligible the question is reduced to: "Can the brown survive in the north?" which is a quite different proposition. If, however, the pure-blood negroes are entering northern latitudes in considerable numbers relative to the hybrids, then the factors of occupation, residence, sanitation, etc., must necessarily be determined separately for each racial element, in order to approach a fair answer to the question of the colored man's ability to survive in the north. If it is true that differences exist in the negro and the brown respecting immunity to certain forms of disease, and if the southern colored man is exposed to these diseases in the states into which he has entered, then the expectation of differential morbidity and differential mortality would be justified. Evidence as to which elements are, and which are not, resistant to these diseases might be disclosed. Such differentiation giving precise and important information toward the solution of this problem is possible only when the racial constitution of the immigrant groups is recognized.

Beginning with the year 1850, the United States census presents figures on both negroes and mulattoes. The term mulatto is unfortunate since it has a specific meaning and is not applicable as a general name for the group of hybrids as a whole. Furthermore, because of the known technical difficulties encountered in separating blacks and browns, already referred to, the census figures can not be regarded as very accurate. Nevertheless, the recognition of these constitutional types in an official record is of great importance. Improvement and ultimate perfection of diagnostic technique, I have no doubt, will be attained, and will form an important and available source of vital statistical material.

Many uses of such data will occur to any one: to learn the ratio of brown to black population in successive decades, to determine the proportion of either to whites and to the total population, and for calculating the rate of increase of these biologically distinct elements, etc. A matter which has become apparent through the census reports is the decline in the rate of increase of both white and colored constituents since the first census was taken in 1790. The rate of increase in the white population has been greater, even after subtracting the annual accessions to it by foreign immigrants, than that of the colored. Since the year 1880 the decline in the colored rate of increase has been rapid—from an increase in 1880 of 34.9 per cent. of the previous decade, to 6.5 per cent. in 1920. The differentiation of browns and blacks in the census reports based on improved methods of examination inspires hope of ultimate success in discovering causes affecting the decline in the rate of increase, *e.g.*, by showing possible differences in the rate correlated with constitution and geographical distribution.

Very little is known about the birth-rate of the American negro and nothing concerning the differential birth-rates of blacks and browns. Records giving the necessary information in this important question are only now becoming available: the registration area for births in 1916 included only one southern state. To-day the area does not include Texas (with a large colored population) and New Mexico where the laws are under trial, nor Nevada and South Dakota. Georgia and South Carolina were added to the birth registration area this year; Missouri in 1927. Even after all the states have been included, one decade, at least, must elapse before a set of figures on the birth-rate comprehensive enough for investigations of the American negro can be used with confidence.

It is hardly necessary to draw attention to the dependence upon a knowledge of the birth-rate for

the solution of many problems of scientific interest and of practical importance: the sex ratio of the new born in the brown and in the negro; the differential infant mortality in these types; the incidence of disease and the cause of death in infancy.

A phenomenon which demands careful study, for which, without doubt, the preliminary fundamental operation of separating the negro and hybrid is indicated, is the rise in death-rate of the colored man in early middle life. Phthisis is suspected as the principal cause, and there is much evidence now that unsanitary surroundings exert a powerful influence. If we knew to what extent each element of the colored population suffered by this untimely entrance of death, we should have in our possession important evidence to make use of in discovering the various factors entering into the phenomenon: perhaps, for example, a correlation is present between sanitation and the constitutional type, whether pure blood or mixture.

Further illustrations pointing to the necessity for studying the racial constitution in connection with outstanding problems of the American negro may be cited in the domain of medicine.

Malarial disease is a tremendous factor in crippling industry in the south. The malady not only physically incapacitates but dulls ambition, destroys enterprise and lowers the morale. The stigma of "laziness" falls upon a malaria-infected population.

There is a persistent and wide-spread belief that in a certain degree immunity from malaria characterizes the negro. Hirsch[2] in studies of the geographical distribution of disease brought out evidence of the relatively high resistance in the adult African negro against malarial infection, but believed that his immunity was acquired. Mary Kingsley[3] has commented on the lesser resistance to malaria of American negroes returning to Africa than that in evidence among native Africans. Stiles[4] writes of the *relative* immunity of the American negro to malaria in pointing out the black man's part in spreading the disease. Many references to the existence of a certain degree of malarial immunity in the negro appear in the literature. Finding the incidence of the morbidity and mortality of malaria in blacks and in browns might be expected to show differences if, as is claimed, the negro is partly immune, the expectation, perhaps, being a higher incidence in the hybrid because he is in less degree a negro.

"Pulmonary tuberculosis is by far the most important single cause of death among the colored, having a rate of 202 per 100,000." The rate given[5] for whites is 85.7. These figures from the death registration area of the southern states are of the year 1920. According to the most recent report of the Metropolitan Life Insurance Company[6] the improvement in the death-rate from tuberculosis has been slight in the case of negroes in the last three years, but shows a marked gain when compared with earlier records.

It has been remarked that the discrepancy in susceptibility to tuberculosis between whites and negroes proved by many observations is too great to be charged to differences only in the sanitary surroundings and that it indicates the probable influence of constitutional weakness in the colored man. Does the brown man offer a greater or lesser resistance than the black negro? This question is of interest when the negro's ability to live in cities is considered.

One other reference to the question of differential immunity: the resistance of the negro to infection by yellow fever is recorded again and again in lay and medical literature. Recent references are cautious regarding this racial immunity. Yellow fever has been nearly eradicated from the western hemisphere but is still a menace in parts of the eastern hemisphere where the white man has economic interests and responsibilities. How does the negro in yellow-fever regions react to the virus? Has he acquired a tolerance or is there a constitutional resistance to infection which saves his life when the white man exposed to the same poison would succumb?

Very interesting observations have been published concerning the blood vascular system of the negro. Data on blood pressure indicate that this tends to be lower in native African negroes than in Europeans. Donnison[7] has observed a consistently lower systolic and diastolic pressure in African negroes from forty years of age and upward as compared with whites. Hypertrophy of the heart was found to be exceedingly rare. Davenport[8] has given the incidence among drafted men in the U. S. Army during the World War as 4.39 per 1,000 for negroes and 2.86 for white men. It has been asserted more than once that cardiovascular diseases are correlated with civilized life, a reaction to the nervous strain. Whatever the cause of the frequency of hypertrophied heart in the American negro, the question is pertinent here respecting its incidence in blacks and browns: are the latter less subject to enlarged heart and high blood pressure than are the full-blood individuals?

Of all the questions touching the American negro, that concerning his intellectual ability is of the highest

[2] New Sydenham Society's Publications, 1: 197.
[3] "West African Studies," p. 54.
[4] Bull. North Carolina Bd. of Health, 23: 33–39, 1908.
[5] Public Health Bulletin, No. 174, 1928.
[6] Statistical Bulletin IX, No. 10, October, 1928.
[7] "The Blood Pressure in African Natives," *Lancet*, 216, No. 5497, p. 6. 1929.
[8] "Defects in Drafted Men." Table xxxvi. 1920.

interest, both theoretically and economically. Investigations of this problem, complicated as it is by intricate environmental factors that are often subtle and inconspicuous, have yielded but scant returns in proportion to the effort expended. Something has been learned in a rough and unscientific way of the colored man's mentality by observation of his brief experience in contact with civilized life. In entering into this new environment suddenly, without a racial experience of a long period of struggle and gradual transformation, such as has been the history of the white race, what are the colored man's chances of fitting into the white man's scheme of things? Is the pure-blood negro so stabilized in his nervous organization, in racial habits, as to be limited to fewer lines of thought and work and cooperation in civilized life, or does no such restricting influence exist in his constitution?

In certain recent studies of the mentality of the colored man, a selection of groups based on racial constitution has been carefully considered and in a number of instances carried out as accurately and completely as the methods for obtaining the criteria would permit. Distinguishing the less negroid from the more negroid is about as much as can be expected from the present technique. Of the two groups separated, one will contain all hybrids, the other pure-blood negroes and probably some hybrids. Even this imperfect separation affords a fairer basis for subsequent studies of ability than was given when no distinction at all was made between blacks and hybrids. It is obvious, however, that the analysis must be pushed much further with the expectation eventually of determining the kind and amount of racial mixture present in a given individual.

May I at this point digress somewhat from the argument in order to refer to the deduction drawn from the history of the black race, namely, that the mulatto is superior to the pure-blood negro, and to mention the factor which beclouds this conclusion, called by Reuter[9] the "cultural advantage of the mulatto." Quoting Reuter: "Speaking generally, the intellectual class of the race is composed of mulattoes; a black man in the class is a rather rare exception." Reuter argues that the mulatto's superiority should not be accounted for solely on the basis of the white element in his constitution, since he has enjoyed cultural advantages throughout the period of slavery and continuing to the present time, which have been denied the black man. Variations of the cultural advantage in any degree whatsoever, whether in the home life or in school, must influence the behavior in childhood and exert far-reaching effects upon progress and success in later life.[10]

The few illustrations offered, will, I think, suffice to make clear my purpose, *viz.*, to invite attention to the factor of race constitution which, in the study of the problems of the American negro, has not received sufficient recognition as being essential to a true solution. The examples presented have been taken from the large series of problems of economic importance and were selected because of this fact. My argument can, however, be sustained by another category of examples chosen from the field of theoretical questions of broader scientific interest, well known to the anthropologist and psychologist.

Criticism can justly be aimed at the practice of drawing deductions concerning traits and tendencies of the American negro from observations taken on random groups of individuals of varying racial constitution. Statistics dealing with the colored man are unreliable for inferring tendencies of population growth, adaptation to urban residence, progress in school, etc., when the groups dealt with have not been selected on the basis of uniform racial constitution. The application of results under such circumstances to projects for alleviation, for education, for residence, may lead to serious errors and wasted resources.

[9] "The American Negro," ed. by Clyde L. King, Am. Acad. Polit. and Soc. Sci. 1928.

[10] Emphasis has been laid upon this point in the outline of a plan for the study of the American negro which has been discussed informally by certain anthropologists and psychologists, of which the following is an abstract.

Objection is raised to the mental tests at present in use because they measure acquisition rather than native ability. What the individual can do is determined by many factors including his mental ability, education and the cultural factors of his home and social life. The test comparing the mental capacities of two individuals or groups is competent when both have had equal opportunities to learn what the test requires and when the conditions under which both take the test are the same. In comparing negroes and whites the preliminary conditions are not satisfied when the two groups have the same school curricula; they must have the same home conditions as well. The cultural background must be equalized for both. In order to bring this about it is suggested that an institution be established into which colored infants could be taken at birth or shortly after, there to be reared and educated under the best conditions. The mental development of the infants and children could be determined and compared; comparison of physical measurements under these conditions would be more reliable than those taken when the nutrition of the child is not controlled. There would be the advantages of a permanent staff maintaining definite problems, developing others and refining methods all of which might be applied in extra-mural work; training staffs for African work and employment of methods as a basis for the study of other races. In order to carry through such a plan, it need scarcely be mentioned, a very great expense would be entailed: adequate grounds, suitable buildings properly equipped, a relatively large staff and many experts of the highest grade. The institution must be permanent—years would be required for the collection and study of evidence.

Progress has been made toward differentiating negroid types in our population through the work of government bureaus and by local health boards. Anthropologists of the United States have made valuable contributions in recent years to the subject of the black hybrids; the following among others have shown especial interest in this province of research: Bean, in defining negro types in America; Davenport, in his Jamaica studies; Estabrook and McDougle, in their analysis of mongrel Virginians; Herskovitz, working in urban negroid colonies; Hooton, by collecting negroid family lineages; Hrdlička, by studies of colored children and of African colonies; Schultz, investigating the negro fetus; Todd, in anatomical research upon the negroid skeleton. These lines of research, so fundamental and so necessary in connection with other problems of the negro, should be encouraged by the most generous support.

Progress in the solution of negro problems will follow the extension of the registration area for births and deaths into those states where at present the laws are not established. Continuation by the census bureau of efforts developing more fully plans for cooperation with the anthropologists would contribute materially to the at present incomplete knowledge of the racial constitution of our population. The Public Health Service is in position to furnish more accurate information on such questions as that of immunity whenever the basis of racial constitution has been laid. The great insurance companies are establishing valuable records available for research, and their cooperation is essential in learning the characteristics peculiar to the negro and to the brown hybrid relative to disease.

It seems to me that there is no problem before American anthropologists more urgent or more fundamental than that of the race mixtures represented in our American negro hybrids. Delay in attacking this problem will entail an increase in its complications. Vital questions are awaiting solution in the absence of a definite knowledge of race constitution.

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## THE AGRICULTURAL EXPERIMENT STATION—AN INSTITUTE FOR FUNDAMENTAL RESEARCH IN RURAL AFFAIRS

### I

NOT many years ago scientists discussed with sometimes more and seldom less heat the comparative merits of pure and applied science. To-day the reverberations of those thunderous discussions grow gradually fainter and fainter. But do not be deceived! The arena of the discussion has merely shifted, and the shift has been only on the pages of the dictionary. Research, impeccably pure in quality, emanating, nevertheless, from the realm of applied science, has effectively gassed the gunners who proclaimed applied science as necessarily impure and defiled. Of course not all of it is pure. Some of it has been, is, and always will be not only impure but impractical, unapplied and perhaps even useless. On the other hand, purity seems no longer to be the exclusive character of the sources of unapplied science, since it is obvious that much of the science springing from such sources is inspired by the hope of practical use, and caustic critics even add that much of our pure science can not claim a high degree of purity, if *quality* be the criterion.

It has therefore become convenient and popular to make a new distinction involving a word found on an earlier page of the dictionary. Fundamental science is now claimed as the peculiar field of those not sordidly engaged or, more accurately perhaps, not definitely paid for their labors in the field of applied science. I have never noticed any insuperable averseness on the part of these same fundamentalists to put their fundamental science to such occasional and profitable use as experts are wont to put it—for appropriate fees. Conversely, it is argued by these fundamentalists in science that institutions and individual scientists whose research is tarred by the stick of usefulness are somehow or other outside the pale of fundamental science, incapable of its pursuit or positively unethical in attempting to invade this sacred field.

Presumably the chief workshop for fundamental science has been located in the general science departments of our universities and colleges, where teaching is supposedly the primary function and research a "by-product of teaching." Where such departments are of sufficient size or enjoy especially generous support, the teaching burdens may be comparatively light or entirely lacking; and opportunity is thus afforded for personal research, together with that more or less vicarious type of graduate student research which has in its turn the by-product of a Ph.D. I have the greatest respect and profoundest admiration for the contributions such departments have made, not merely as the chief or well-nigh only training schools of investigators, but also for the numerous and valuable contributions they have made and are still making in the field of research itself. And I am also one who believes that the academic freedom of the college science teacher, *if* and *as* expressed in his unhampered freedom in the attack

on any problem of science within the scope of his ability and opportunities, is a priceless possession to be treasured by the whole fraternity of science and to be used by those to whom it is entrusted with a reverent appreciation of its worth.

The field of research of the science teacher is of his own choosing. He it is who may direct the activities of research in his department. He may be no less an autocrat in his small field than is a gigantic bureau of the U. S. Department of Agriculture in its larger field of research activities. But academic freedom by no means automatically confers upon the professor the exclusive possession, or even a due appreciation, of what is fundamental in research, and much less the ability to pursue it successfully.

The increasingly large output of research of all kinds: applied, technical, pure or fundamental—call it what you will—outside of college walls, makes it perfectly obvious that the center of the population of working scientists is shifting. And so it happens, since research has become the every-day instrument of national, state and municipal agencies, industrial organizations, and the like, that a new expression, suspiciously suggestive of the former worship of science, pure and undefiled, has come to the fore. The pure-science idol has been rechristened "fundamental" science.

The new temple is called an institute for fundamental research in this or that special field. You will notice at once that this is in the nature of an admission that fundamentalism in science may now be worshiped outside of collegiate sanctuaries, but please also note carefully that these new temples must be specially dedicated to fundamentalism and not defiled by contact with the debasing influences of application. The traditional ghost must still haunt the house dedicated to research for a practical purpose. It is even conceded that application of results may be taken care of by proper affiliation with practical institutions which shall follow in the wake, and apply or polish, by day-labor methods, as it were, the gems of scientific truths brought up from staggering depths by the institute for fundamental research, which seeks only the priceless stones but declines to cut them or put them in their proper setting.

And, behold! One of the greatest of our universities has recently discovered that there is such a thing as a rural problem and forthwith proposes to establish, presumably in the largest urban center on our continent, an institute of rural affairs whose aim

> would be to make original researches in the field of rural affairs and to interpret and give publicity to the best available knowledge concerning the fundamental problems of agriculture and country life, the most promising methods of their solution, the relationships of the urban and rural groups, and the international aspects of the farm question.

A modest program indeed! And perhaps our existing forty-eight institutes of rural affairs may now rest on their shovels, or hoes, or what have you?—and complacently view from afar their problems solved by the diggers in the subways and the sweepers on the sidewalks of New York.

When it is pointed out that institutions already exist for research in such special fields, the reply is prompt that such institutions are engaged in practical research and not suitable for research in the fundamentals—which may or may not at all be true. It is said that such institutions are pressed for results of practical value and for immediate use, and that such demands preclude the possibilities of the deeper digging which may uncover underlying veins of richer ore. While this contention is justifiable in many instances, it is just as true that the time-honored sources of fundamental research in our colleges and universities have equally distracting activities in teaching and administration. Indeed, such institutes for fundamental research as already exist can hardly be said to have completely established the hypothesis that dissociation from application of their results has made them conspicuously successful in their primary function of fundamental research.

Does the history of science show that a segregation of laborers into fundamental researchers and the garden variety polluted with practical objectives has resulted satisfactorily? Can the two types of research, if there are two types, be separated? And, if possible, is it even advisable to do this? Can fundamental research and application go hand in hand?

Certainly, Pasteur was engaged in solving exceedingly practical problems. And perhaps Newton was supposed to be picking the apples instead of waiting for them to fall.

The truth of the matter is that such a distinction between fundamental and applied science is purely artificial. "Fundamental," as applied to problems in science, is merely a relative term. If pressed to a logical conclusion, only those problems which deal with the ultimate constitution and origin of the simplest units of matter may be considered as fundamental to all of the physical and biological sciences. The physicist or physical chemist—I am never quite sure which of these two is overlord of those ultra-basic problems—would thus, in the last analysis, be the only simon-pure investigator of fundamental problems. Of course, the grand old army of working scientists is not for a minute going to agree to this conclusion. Each and every one of them is perhaps secretly hoping that his researches will turn up one of these priceless gems of fundamental value. And

many of them are impertinently frank enough to tell the world of their hopes—yea, even their confident expectations!

No, there is something just a little dubious, not to say utterly fallacious, about this apparently desirable and conveniently discriminating distinction between fundamental and applied science.

Fundamental, I repeat, is merely a relative term. One fact or process or phenomenon is merely closer to the bottom of the question; it is nearer the basement or the sub-basement. Research starts from a known field or stratum of facts and proceeds to the field of the unknown. Facts for which we have causal explanation are of greatest value in science and permit of natural classification. When groups of facts, even though not apparently related, are shown to be connected by a common causal agency, you have a more basic fact or cause. Just so may isolated outcrops of ore be connected with a common ore body far below the surface. But "fundamental" to this, again, lies the contribution which shows the exact geologic formation which will produce such an ore body and the certainty of predicting such an ore body from similar formations.

Research logically and methodically proceeds from known facts to the immediately preceding or underlying facts—all of them are more fundamental. The new facts may prove to be of importance only in explaining the particular phenomena under investigation. They may be of no practical value or they may be of enormous importance practically. But sometimes one of these innocent-looking facts, turned up perhaps by the lone digger, may be connected with another or with a great series of other phenomena, and then the scientific world announces a great piece of fundamental research. Perhaps the original discoverer, so completely absorbed in his own particular shaft, never senses the relation of his newly discovered fact to the other groups of phenomena to which it may be fundamental, as a child who has found a valuable diamond might merely add it to his collection of pretty stones. It is true that we have too many of such investigators working in practical science, but they are not unknown in the field of pure science.

Now the fundamentalist in research would reverse this process in a certain sense. His institute would not bother about the smaller veins of ore—slight contributions of knowledge. It would seek only those diamonds of Kohinoor size. It would strike directly for the great ore bodies that lie far below the surface. How big must these ore bodies be? The fundamentalist can not tell you that. The biggest ore body, basic to all of the rest, is the constitution of the ultimate unit of matter. But between that body and our present knowledge lie untold depths of unexplored ground through which we must dig our biological, chemical, geological and countless other shafts. The institute dedicated only to fundamental research would be like the miner who would sink a shaft far below the bottom of all existing shafts and then start his horizontal exploration with the hope of finding facts of great importance to all the diggers above. Of course he might do that very thing, but how would he know that the new vein of ore actually connected with one or all above? "Well, that," he says, "is a practical problem and we are not interested in it."

More than sixty years ago an Austrian monk became interested in growing peas, the edible garden variety as well as fundamentally educated peas, round peas that roll easily off the knife and square ones that do not. Perhaps he was not so practically minded in his researches as to care particularly about the balancing power of peas. He made investigations and discovered a real research gem of very great biological value. It seems hardly possible that Mendel could have realized the fundamental importance of his discovery. Certainly, the scientific world of his day either overlooked it or failed to appreciate it. For forty years Mendel's shaft lay unnoticed, sides caved in and the opening obscured by weeds. Then simultaneously in three different places in Europe Mendel's law was "rediscovered," and the fact of its fundamental importance in a better understanding of heredity was heralded to a breathless scientific world.

Perhaps Mendel's monastery was the prototype of an institute for research in genetics. I am more inclined to think he ran a sort of farm and was moved by the same spirit as a good experiment station worker of to-day. I think he probably liked peas, both round and square, and had a genuine scientific curiosity and an inquiring mind. He may even have had in mind the simple matter of developing a superior round pea in order to discourage as much as possible those of his brethren who still clung tenaciously to the vulgar belief that the knife was a more effective conveyor of peas than the fork. Or maybe he merely said to himself, "I wonder, when I cross these round and square peas, if they will all stay on or fall off of a knife." Now whatever Mendel had in mind, his research, though lost for forty years, is quite universally accepted as fundamental. Any research institute for plant genetics would gladly enrol "Mendel's laws" in its own historical record. It is equally true that Mendel's results were of immense practical value, not merely in the certainty of growing ideally poised and superbly balanced square ones, but everywhere and otherwise in the field of plant and animal breeding.

Facts of fundamental importance may lie in the path of any digger after the truth. He may be digging for gold, platinum or precious stones, for Indian arrow-heads, for prehistoric bones, or he may merely be digging potatoes. It can perhaps be claimed that the importance of research contributions is roughly proportional to the depth at which they are found, that conditions and circumstances greatly influence contemporary judgment. Mendel died entirely unconscious of the value which history places on his discovery. Researches heralded as epic sometimes turn out to be investigational "duds." We have recently witnessed such a one with a tragic ending. The significance of facts is frequently not appreciated until their relations with other facts are worked out by succeeding investigators. Science grows largely by the small accretions of apparently insignificant contributions, each one fundamental to its predecessor. Milestones may be marked by exceptional finds or, again, merely by the addition of an apparently insignificant fact which fortunately completes a puzzling design.

The conclusions which I am forced to draw then are: first, that any attempt to exclude fundamental problems from applied science not merely ignores dictionary definitions, but, what is far worse, gives a distorted picture of the nature of problems in science, of methods of research and the history of its growth; second, that fundamental results of the most fundamental importance are not at all incompatible with research in applied fields, provided the investigator keeps on digging at the bottom of his shaft and not merely enlarging its entrance.

## II

Is there anything really grotesque in the idea of a state agricultural experiment station functioning as an institute for fundamental research? I can not see that there is. More than that, I can not conceive of an agricultural experiment station which is living up to its duties and responsibilities which is not engaged in at least some problems of fundamental research. Experiment stations have justly earned a reputation for practical research; they have established beyond doubt a devotion to service in the improvement of agriculture. Are they also actually engaged in fundamental research? My observation is that some of them are to a high degree, many to perhaps a limited degree, and to some perhaps such research is entirely foreign.

I have already taken considerable pains to establish to the best of my ability the fact that fundamentalism in research is merely relative. A similar relativity is also observable in the work of our forty-eight or more agricultural experiment stations and needs little or no amplification. Some experiment stations are more fundamental than others. Our experiment stations as a whole are not regarded in the world of science as institutions largely devoted to fundamental research, and rightly so. Perhaps this is as it should be, and then, again, perhaps it is not.

How do we get this reputation for shallow rather than fundamental research? Too frequently our investigators, after sinking their shaft and bringing out ore of practical value, stop digging at the bottom and merely enlarge the opening. This frequently results in a maximum amount of practical results at minimum effort and expense—like open pit mining.

As an illustration, take new and better varieties of wheat. Our first shafts sank to the level of merely empirical testing of known varieties and more or less careful selection. We expanded the opening by the importation of varieties from all parts of the world. Everybody was testing varieties and writing voluminous bulletins filled with a few facts surrounded by oceans of useless information or misinformation. Then came a few deep diggers who made empirical crosses, with little or no knowledge of what was happening in these matings of strange varieties. From crosses without number and plots in endless array, here and there emerged new and valuable wheats, and the opening was again enlarged by scores of imitators in as many experiment stations. Desirable varieties shot forth like meteors, only to disappear under the cloud blanket of our ignorance of pure lines and genetics. Then came a third group of fundamentalists equipped with knowledge of Mendelism, mutation and other newer instruments for digging. Intelligence in crossing and a greater knowledge of how to produce specifically desired varieties were the results of this new series of shafts. Again we find the army of open pit investigators enlarging the entrance on this new level, with their endless correlations in inheritance of this, that and the other character to this, that and the other habit. And in the meantime the true fundamentalist is again sinking a new shaft. It seeks the chromosome in the wheat cell; it demands a knowledge of the intimate structure of the chromosome and the relation of its parts to the character factors in heredity. Fundamental, indeed! and getting fundamentaler! The wheat breeder is now talking a language no more intelligible to the farmer—and perhaps to his station director—than Greek or Sanskrit.

And how about it, Mr. Director? Is this practical? Can you stand for it? Are you going to get results? Well, who knows when you will get results in fundamental research? Research is an exploration of the unknown. Your investigator may come home with a valuable side of the bacon of achievement, or on the

other hand he may lose his airship and most of his men and equipment. But of such stuff is fundamental research made! Have you faith in it? Are you convinced that digging deep solves, in the end, more problems in a sounder fashion? How great is your faith? How strong are your men? How well are they equipped? Do you give them hearty support? Or are they a little apprehensive that you will choke off the air supply and leave them to suffocate far below the surface? Are you seeing that they cooperate with each other for mutual protection and help? Has your plant breeder ample support in pathology, physiology, soils and biochemistry, or is he way down there all alone with only one life-line?

If you lack that faith, you would better stay near the top and keep your whole staff there. Mining was always a dangerous business, and fundamental research is equally hazardous. And, after all, hole amplifiers and open pit miners are useful citizens of the scientific brotherhood. Sometimes a shallow digger who covers much ground finds the top of a new and valuable ore vein.

Now, of course, no experiment station or, for that matter, any other institution for fundamental research, could possibly afford to sink deep shafts into every problem laid at its doors by the agricultural public. Every director knows that these problems are myriad in number, each one backed by insistent demands and earnest clienteles. Our resources, though generous indeed, must be carefully husbanded. You must have competent investigators for any deep digging, and their number is even as the proverbial dental equipment of the domestic fowl. Such researches demand modern equipment and ample support. It is quite obvious that you will have to discriminate. Here and there you will concentrate, perhaps, on a few deep shafts, but not in every department. But if we are to make real progress, some one will have to attack the bottom of the shaft.

Your state and your station may be eminently suited for an attack upon a specific problem of vital economic importance to other states as well as to your own. A deep shaft in that field will yield truly fundamental results, if not actually in a more basic solution of the problem, at least in minor or even negative results of value. And do not overlook the morale which ideals of courageous and serious research build up in your whole staff of investigators.

No experiment station that encourages shallow digging or a gleaning process in its research to the exclusion of fearless fundamental investigations, no experiment station that demands of its staff that all of its results be expressed or understandable in the simplest terms of extension circulars, is worthy of the name of an institute of fundamental research or, for that matter, of the name of a real experiment station. Your courage needs only the faith that below the level of our present knowledge lie facts of ultimate value in the application as well as the theory of scientific agriculture.

Quality of research, not quantity, determines the status of an experiment station in the brotherhood of institutes for fundamental research. Not the number of shallow and wide open pits but the depth of its deepest shaft. One deep shaft may bring in a gushing oil well where scores of shallow pits remain dry.

And make no mistake about it—such shafts are steadily being sunk in experiment stations all over our land. They are ample justification for the inclusion of agricultural experiment stations among the institutes of fundamental research.

Our greatest experiment station, the U. S. Department of Agriculture—and probably one of the greatest institutes for fundamental research in the world—is honeycombed with shafts of basic research. The field of bacteriology owes a tremendous debt to the outstanding researches of the late Erwin F. Smith and his coworkers. Can there be any question of the fundamental nature of those investigations? The work of the Wisconsin Experiment Station in its fundamental attack on the relation of temperature to plant diseases would reflect credit on any institute for fundamental research. The Minnesota station, cooperating with the Cereal Office of the U. S. Department of Agriculture, has sunk deep the shaft of physiologic forms in the study of rusts of wheat. The minute and difficultly measured differences in infection behavior of rusts from various sources have required years of patient research, apparently far removed from the field of application. Yet these results have not only proved of primary importance in the breeding of wheats for rust resistance, but they have also brought about a profound change in the fundamental methods of attack in the investigations of plant diseases all over the world. The investigation of any plant disease to-day is incomplete without a knowledge of the possible physiologic forms of its pathogene. Varietal resistance to disease becomes more intelligible and hence more easily obtainable because of this shaft which has opened up the rich ore body of physiologic forms. Small wonder, therefore, that in May, 1928, at Copenhagen, Denmark, the Emil Christian Hansen prize and medal was awarded to a Minnesota Experiment Station investigator "in appreciation of the pioneer work accomplished by him in developing new ideas and methods for investigating the rust problem, methods applicable not only to the study of the wheat rusts but to

the investigation of diseases due to the fungus parasites in general."

This is not the place to attempt anything like a true picture of the amount of fundamental research going on in our experiment stations. That it exists in large amounts is quite obvious to any careful observer. I can think of no finer tribute to these great institutions of service and science than such a picture carefully and faithfully portrayed by a discriminating survey. I, for one, shall be disappointed if such a picture does not emerge from the forthcoming survey of Land-Grant Colleges.

But directors of experiment stations who have only the faith in fundamental research are men of little faith. They have only the half of it. The other half is an unquestioned faith in your investigator. His is the lonely and hazardous field of exploration. He it is who is in the unknown forest seeking the way out. Here a deer trail lures him from his path, there a fallen tree makes necessary a detour. Heavy underbrush obscures the trail, and he must quickly follow such judgment as he may possess to determine his direction. Clues and "hunches" necessitate numerous unforeseen exploratory excursions. Trails may end in dense thickets, impassable bogs or steep precipices, and he must retrace his steps. Can you, Mr. Director, swing in the swivel chair of your office and tell him just where to go and what to do? Shall he ask you whether he must turn to the left or right around that fallen tree? Can you show him the way up the steep cliff? If so, you have no need for an investigator. You merely need a timber cruiser or a hired man.

Are you going to make this busy seeker for the trail report every move, every beaver run, every swamp he searches in his quest for the trail? Can he possibly make a detailed project of his every future move? And how much it will cost? Can he possibly tell you beforehand where he is going and what he is going to do? If he is a real and honest investigator, he will say that he doesn't know. He can not possibly foresee all of the obstacles. He is a searcher in the unknown.

True, he needs to have in mind a general project of his search. He must have a definite trail in mind. He is not merely camping or fishing for pleasure. He seeks a northwest passage and he would be hopelessly lost without a tentative chart of his proposed travels. But once started in the woods, he is on his own. His must be the decisions, his the responsibility. All that is left for the director is faith in his emissary. Of course, if he's gone too long and probably lost, a relief expedition may be necessary, or he may come back for larger supplies and more men. Then must the director decide the advisability of continuing or abandoning the search—of renewing or withdrawing his faith in his investigator. I take it that a station director, like the director of any other institute for fundamental research, needs an inexhaustible store of faith. And please don't forget that such faith can be quite tangibly expressed on the payroll in figures that are concrete demonstrations of your appreciation of the importance of this man and his work. For "faith without works is dead!"

It was a poet and not a scientist who so charmingly advocated safe and hopeless mediocrity: "Be not the first by whom the new is tried nor yet the last to lay the old aside." Our "jazzy" but withal discriminating youth of to-day repudiate that advice when they slangily reply, "We'll try anything once!"

I believe an agricultural experiment station should engage in solving the practical problems of agriculture; I believe that it should render real service to agriculture and thus to the whole people; I believe that it should extend its knowledge to all the people by every legitimate method; and last, but not by any means least, I believe that it should contribute generously to the investigation of those deeper problems which lie at the bottom of our present knowledge in every field of agriculture. Then, indeed, will it be able to render the greatest possible service to agriculture through a more profound knowledge and a more fundamental solution of practical problems. Then will it be secure in its conviction that its numerous and ever-branching streams of extension activity flow from a deeper and clearer source of knowledge. Then, and only then, may it lay claim to its proper title as an Institute for Fundamental Research in Rural Affairs.

E. M. FREEMAN

DEPARTMENT OF AGRICULTURE,
UNIVERSITY OF MINNESOTA

## SCIENTIFIC EVENTS

### THE STUDY OF AGRICULTURE IN NEW YORK STATE

GOVERNOR FRANKLIN ROOSEVELT sent to the New York State Legislature on March 17 three bills, the last of his farm relief measures, based upon the recommendations of his Advisory Agricultural Commission.

The bills submitted call for appropriations totaling $168,530 for investigation into problems of interest to the farmer, varying from crop adaptation and soil conditions to cooperative marketing and rural government. The work would be done by three state agricultural institutions.

The governor's message to the legislature, accompanying the bills, follows:

Many farmers in the state are asking for constructive assistance in the solution of certain problems in the management of their farms and in their business which call for expert scientific research. This assistance must come from those who by training and experience are in a position to deal fundamentally and comprehensively with the specialized technical and scientific problems involved.

I, therefore, recommend the passage of three bills which have been prepared, for investigations, research work and for necessary personal service, and construction work incidental thereto, by the New York State College of Agriculture at Cornell University, the New York State Agricultural Experiment Station at Geneva and the New York State College of Home Economics at Cornell University.

These bills provide for appropriations totaling the sum of $168,530 to be spent on investigations of muck land problems in their soil and pathological aspects, crop adaptation, fertilizing and cultural practice, potato diseases, city markets, regional readjustments and development of cooperative marketing, rural government, animal husbandry, peach moths, codling moths and allied insects, and the question of living costs on the farm.

These expenditures have been recommended to me by the Agricultural Advisory Commission which I appointed last December and represent the minimum of what ought to be done this year to help the farmer to meet his farm problems.

## THE "SLOTH PIT" IN NEW MEXICO

THE Peabody Museum of Yale University and the U. S. National Museum at Washington, acting jointly, sent an expedition on March 25 to New Mexico to excavate completely the extinct fumarole in which the fossil of the Yale ground sloth was found. Yale will be represented in the expedition by Fred W. Darby, in charge, and the National Museum by N. H. Boss. Ewing Waterhouse, of El Paso, Texas, one of the discoverers of the sloth, will assist the party. It has been agreed that all bones recovered will be divided between the Peabody Museum and the National Museum, with the understanding that, should another sloth be found, it is to go to the National Museum.

The work is to be done in Dona Ana County, New Mexico, about forty-five miles northwest of El Paso, Texas. This is an extensive volcanic region where lava flows are a characteristic feature. Near the town of Aden lies the low cone of an extinct crater rising about two hundred feet above the surrounding country. Within the crater the floor is flat, about a quarter of a mile across, and is sparsely covered by cacti and other desert plants. On the east side the crater rim is broken by a gap which forms a passage into the interior, with gradually narrowing walls. In the floor of this passage lies a seemingly bottomless pit, the aperture of which is about eight feet in its longest diameter and covers the entire width of the passage. This forms a natural death trap, and it was into this pit that the sloth now at Peabody Museum blundered, possibly when pursued by wolves.

At a vertical depth beneath the surface of about one hundred feet is a cavern full of bat guano, the accumulations of thousands of years, in which the sloth was found. The guano afforded the means of preservation of the entombed fossils. This cavern, which is estimated to contain about ninety tons of bat guano, will be excavated by the expedition. This means sifting the guano with fine-mesh sifters to insure against the loss of any bones, no matter how small, either fossil or recent.

As but little of the guano deposit has been disturbed, it is believed that more specimens will be found contemporaneous with, or older than, the Yale sloth, which may be upward of 500,000 years old. Professor Richard S. Lull, director of the Peabody Museum, has said that while the place could never have been occupied as a den, "it is hardly thinkable that our sloth was the only unfortunate of his day to blunder in."

## RESEARCH ON DEAFNESS

GIFTS aggregating $40,475 for research into the cause and cure of deafness were announced at a luncheon held on March 20 in the Hotel Commodore by the laymen's committee which is assisting the American Otological Society's Research Fund Committee in an effort to reach its goal of $500,000 by June 30.

These gifts are to become a part of the $2,500,000 permanent fund which the Otological Society, a branch of the American Medical Association, hopes to collect for a study of diseases and affections of the ear in the hope of discovering methods of dealing with the problem of chronic progressive deafness. The society is particularly concerned over those varieties of deafness, including otosclerosis, for which no cure is known at present.

Dr. Edward B. Dench, New York otologist, who was present at the luncheon representing the board of trustees of the research fund of the society, emphasized the importance of having $500,000 available by the end of June in order that the important research work which has been started in several medical institutions under a grant by the Carnegie Corporation need not be interrupted. Dr. Dench made the statement that one out of every four persons in the United States is suffering from hearing defects of some sort.

The campaign was announced at a dinner given last week at the New York Academy of Medicine to a group of prominent otologists and interested laymen.

Among the persons who have contributed to the fund are Mrs. Helen Hartley Jenkins, of New York City, who gave $25,000 through the Hartley Corporation, and Mrs. Charles H. Stout, of Short Hills, New Jersey, who donated $10,000.

## THE TORONTO MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

THE spring meeting of the society is scheduled for May 27, 28 and 29. Many of the members expect to arrive in Toronto on Sunday, in order to give themselves an opportunity to become acquainted with the metropolis of Canada. At Toronto are located 3,600 manufacturing establishments, with an annual output of various products amounting to $60,000,000. North of Toronto are the great mines of Ontario, which are responsible to a large measure for the city's prosperity.

The reduced railroad rates go into effect on May 15, and there will be a large attendance of members and guests residing in the western part of Canada and the United States. The headquarters of the meeting will be at the University of Toronto. The spacious, well-equipped dormitories will be used as sleeping quarters. The university students will have left the week previous, so that the university facilities will be at the disposal of the society. Members and guests are urged to communicate with Professor W. Lash Miller, chairman of the local committee, at the university, and make their reservations for rooms well in advance of the meeting.

Monday afternoon will be devoted to an open discussion, to which guests of members are cordially invited. The topic will be the present status and future developments of the electrochemical industries of Canada, including aluminum, cyanamide, copper, carbide, acetone, etc. There will be a formal paper presented to introduce the topic. The discussion as a whole will not be recorded—pursuing the same policy that has prevailed at the round table discussions. Members will have an opportunity to get the latest reports on the power available for electrochemical industries, raw materials, cost of transportation, markets, new products and their applications, etc.

The main scientific session will be devoted to papers on "Electro-Magnetic Characteristics of Electrochemical Processes." Six papers have been listed for this interesting topic. The papers cover the phenomena experienced not only in solids and solutions, but also in gases. Mr. Floyd T. Taylor, of Matawan, New Jersey, will be in charge of this session.

A session on modern methods of teaching is in charge of Professor Roy L. Dorrance, of Queen's University, Kingston, and promises to be of interest not only to teachers and students, but also to many of the industrial men who strongly favor radical changes in presenting the subject of electrochemistry to the young student. The modern electrochemist must not only be a good chemist, but he must also be an expert in electrical engineering and metallography, and, above all, must have a full appreciation and understanding of engineering materials and costs. Among those who will participate in this discussion are Professors Stansfield, Sheean, Thompson, Parker, Brockman, Furman, Kahlenberg and Kremers.

Professor Harry A. Curtis, of Yale University, will address the society on Tuesday evening, May 28, on "The Nitrogen Fixation Factories of the World." The address will be illustrated..

On Wednesday morning, May 29, there will be a joint session with the American Electroplaters' Society, Toronto branch. On Wednesday afternoon there is also scheduled a joint session with the Canadian Chemical Association.

Plans for visits to industrial plants have been made.

## RESEARCH IN AGRICULTURAL CHEMISTRY

As has already been announced, the first award under the Frasch Foundation, established by the will of Elizabeth Blee Frasch for "research in the field of agricultural chemistry," has been made, giving half of the award, $20,000 annually over a period of five years, to the Boyce Thompson Institute for Plant Research in Yonkers, New York; $12,000 annually to the University of Missouri, and to the University of Wisconsin, $8,000. The committee of five who advised the directors of the American Chemical Society as to the award included: R. W. Thatcher, *chairman*, W. D. Bigelow, C. A. Browne, John Johnston and F. R. Moulton. The fund is administered by the United States Trust Company, upon the legal advice from the directors of the American Chemical Society.

It is proposed that the funds be applied mainly to salaries, the institution obtaining the award to supply the equipment and materials for the investigations. In the case of the Boyce Thompson Institute, a large laboratory is being equipped especially for this work and Dr. F. E. Denny will handle the research on effects of stimulative chemicals on plant growth, while Dr. Frank Wilcoxon will conduct the special insecticide and fungicide investigations.

At Wisconsin the fund will be devoted to the biochemistry of micro-organisms in connection with fermentation studies already under way, while at Missouri the project is entitled "The Efficiency of the Animal Growth Process at Various Ages and under Various Conditions of Management."

Annual progress reports are to be made and probably a series of monographs issued on the completed work.

## THE FIFTIETH ANNIVERSARY OF THE U. S. GEOLOGICAL SURVEY

The U. S. Geological Survey, one of the veteran bureaus of the government, celebrated on March 21 its fiftieth anniversary. Members of the survey were received by President and Mrs. Hoover at noon. During the afternoon a meeting was held at the National Museum and addressed by Ray Lyman Wilbur, secretary of the interior; Henry Fairfield Osborn, John C. Merriam, Arthur E. Morgan and other distinguished scientists. Director George Otis Smith presided. This meeting was followed in the evening by a dinner at the Washington Hotel in which some six hundred friends of the survey participated.

Summarizing the growth of the bureau in these fifty years, speakers pointed out the fact that it came into being with the appointment of its first director, Clarence King, on March 21, 1879. Thirty-five years ago President Hoover was a member of its staff working as a field assistant in geologic mapping in the Sierra Nevada between college terms at Stanford University. During its half century of activity, it was said, the survey has graduated thousands of trained engineers and scientists who are now working in all parts of the world.

The appropriations for the work of the survey have increased from $100,000 for the fiscal year 1880 to over $2,000,000 for the fiscal year 1930. The total expenditures during the life of the survey have been about $75,000,000, including nearly $10,000,000 of state cooperative funds. The published reports by which the Geological Survey's work are made available aggregate over 400,000 pages and occupy 120 feet of shelf space. Other organizations which are in a real sense children of the Geological Survey, their work having been started by the survey, include the Bureau of Reclamation, the Bureau of Mines, the Bureau of American Ethnology, the Forest Service and the Geophysical Laboratory of the Carnegie Institution.

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## SCIENTIFIC NOTES AND NEWS

The executive committee of the American Association for the Advancement of Science will hold its regular spring meeting at the Cosmos Club in Washington on Sunday, April 21, with a forenoon, an afternoon and an evening session. Business to come before the committee at this meeting should be in the permanent secretary's office in Washington by April 15.

Robert Ridgway, curator of the division of birds in the U. S. National Museum since 1876, died on March 25, in his seventy-ninth year.

Arthur Mastick Hyde, formerly governor of Missouri, who was appointed Secretary of Agriculture by President Hoover, took the oath of office in the administration building of the department in Washington on March 6, in the presence of the outgoing secretary, William M. Jardine.

On the occasion of the fiftieth birthday of Professor Albert Einstein on March 14, the city of Berlin presented to him a tract of land on Havel Lake near Potsdam where a summer home will be erected. Among the scientific honors conferred upon Professor Einstein on his anniversary was his election to honorary membership in the natural science faculty of the University of Paris.

Professor Frank Schlesinger, director of the Yale University Observatory, has been awarded the Bruce medal of the Astronomical Society of the Pacific for his work on photographic parallaxes and in other departments of astronomy. The medal is awarded on the recommendation of the directors of the Harvard Observatory, Lick Observatory, Yerkes Observatory, the Observatory of Berlin, the Observatory of Greenwich and the Observatory of Paris. It will be presented to Professor Schlesinger at a special meeting of the society which is to be called at New Haven on April 12.

Dr. Charles F. Brush, of Cleveland, Ohio, distinguished for his work on electric arc lighting, celebrated his eightieth birthday on March 17.

The Iron and Steel Institute, London, has awarded the Bessemer gold medal to Sir Charles A. Parsons, in recognition of his distinguished services in advancing the science of engineering as applied to the manufacture of iron and steel.

Fellows of the Royal Society of Edinburgh have been elected as follows: Dr. S. G. Barker, director of research, British Research Association for the Woolen and Worsted Industries, Leeds; Dr. F. Bath, lecturer in mathematics, University of St. Andrews; Mr. G. Bennet, lecturer in mechanical engineering, Heriot-Watt College, Edinburgh; Dr. A. Calder, assistant in the animal breeding research department, the university, Edinburgh; Dr. G. Coull, pharmaceutical chemist, Leith; Professor E. W. H. Cruickshank, physiology department, Dalhousie University, Halifax, Nova Scotia; Mr. David Kennedy Fraser, psychologist to the education authority, Glasgow; Mr. T. Henderson, actuary of the Savings Bank of Glasgow; Dr. Sunder Lal Hora, senior assistant superintendent, Zoological Survey of India, Calcutta; Professor J. Kendall, F.R.S., chemistry department, Uni-

versity of Edinburgh; Mr. J. R. Little, general manager and secretary of the Century Insurance Company, Edinburgh; Professor D. N. M'Arthur, department of agricultural chemistry, West of Scotland Agricultural College, Glasgow; Mr. J. Mackie, mathematical master, Leith Academy, Leith; Mr. W. Mercer, lecturer in clinical surgery, University of Edinburgh; Mr. H. Moir, president, United States Life Insurance Company, in the city of New York; Professor F. W. Ogilvie, department of political economy, University of Edinburgh; Dr. J. F. V. Phillips, botanist in government service, Tanganyika Territory; Mr. S. Read, schoolmaster, Edinburgh Academy; Mr. R. A. Robb, lecturer in mathematics, University of Glasgow; Principal J. C. Smail, Heriot-Watt College, Edinburgh; Professor Sydney Smith, department of forensic medicine, University of Edinburgh; Dr. Thomas Southwell, lecturer in helminthology, School of Tropical Medicine, Liverpool; Mr. A. C. Stephen, assistant, natural history department, Royal Scottish Museum, Edinburgh; Dr. B. P. Wiesner, lecturer in sex physiology, University of Edinburgh.

A BANQUET was given in Chicago on March 15 in honor of the fiftieth anniversary of professional service of Dr. Albert R. Mitchell. The principal address was given by Dr. Morris Fishbein, editor of the *Journal* of the American Medical Association, of which Dr. Mitchell has long been a trustee.

JAMES A. GAMBLE has returned to the Bureau of Animal Industry as milk technologist after an absence of ten years, during which time he was professor of dairy husbandry in the University of Maryland.

PROFESSOR DONALD M. MATTHEWS, professor of forestry management in the school of forestry and conservation of the University of Michigan, has accepted an appointment as forester on the staff of the Tropical Plant Research Foundation, Washington, D. C. Professor Matthews will continue his work at the university and, in addition, will serve as general adviser on the forestry projects of the foundation.

REAR-ADMIRAL WALTER S. CROSLEY will be a national delegate to the supplementary conference of the International Hydrographic Bureau at Monaco beginning on April 9. Rear-Admiral A. P. Niblack, retired, is president of the directing committee of the bureau. P. de Vanssay de Blavous, France, and Captain di Vascello L. Tonta, Italy, are directors. Commander G. B. Spicer-Simson, of Great Britain, is secretary-general.

RICHARD J. LOUGEE, of Malden, Mass., formerly a member of the faculty of Dartmouth College, will take the place this summer of Professor William H. Hobbs, head of the department of geology of the University of Michigan, who has been director of the Greenland expedition for the last three years.

DR. ALWIN M. PAPPENHEIMER, professor of pathology at Columbia University, is spending the current winter at the School of Tropical Medicine at San Juan, Porto Rico.

DURING the coming spring Professor I. Borcea, of Yassy University, accompanied in all probability by M. Calinescu, inspector of Rumanian state fisheries in the Dobruja, will follow up his discovery of last year of the bones of a mammoth near Ekrene.

THE Cutter lecture on preventive medicine was given by Dr. Edwin O. Jordan, professor of hygiene and bacteriology in the University of Chicago, on "The Epidemiology of Paratyphoid Infections" on March 27, at the Harvard Medical School.

PROFESSOR WALTHER STRAUB, professor of pharmacology at Munich, will deliver the seventh Harvey Society lecture at the New York Academy of Medicine, on Wednesday evening, April 3. His subject will be "The Pharmacology of the Digitalis Substances."

PROFESSOR HENRY NORRIS RUSSELL, of Princeton University, addressed the Swarthmore Chapter of the Society of Sigma Xi on March 19, on "The Composition of the Sun."

DR. W. H. LONGLEY, professor of biology at Goucher College and executive officer of the Tortugas (Florida) Laboratory of the Carnegie Institution of Washington, will give an illustrated lecture before the institution on the evening of April 2 on "The Coloration of Fishes in Relation to their Habits and Distribution."

DR. JAMES A. DOULL, of the Johns Hopkins School of Hygiene and Public Health, delivered the first Delta Omega lecture at the Yale School of Medicine on March 8, under the auspices of the Epsilon Chapter of the society. The subject was "Factors in the Selectivity of Diphtheria and Scarlet Fever." Professor C.-E. A. Winslow presided.

PROFESSOR EDWARD W. BERRY, of the Johns Hopkins University, lectured on "The Origin and Evolution of Floras" before the Royal Canadian Institute on March 16.

JEROME ALEXANDER spoke at McGill University on March 21 to the chemical engineering students on "Colloids" and to the McGill Chemical Society on "Some Physico-chemical Aspects of Life, Mutation and Evolution." In the evening he addressed the

Montreal section of the Society of Chemical Industry on "Vanadium and Some of its Commercial Applications."

*Nature* reports that in commemoration of the bicentenary of Josiah Wedgwood in 1930 the British Ceramic Society proposes to publish a volume of essays, for which two prizes are offered.

SIDNEY S. BUCKMAN, distinguished for his work in geology, particularly on the ammonites and brachiopods of the Inferior Oolite, died on February 26. Mr. Buckman was the son of a well-known geologist, Professor James Buckman.

CONGRESS has provided a pension of $125 a month for Mrs. Mary H. Goldberger, widow of Dr. Joseph Goldberger, late surgeon of the U. S. Public Health Service, in recognition of his service in the study of pellagra. Mrs. Goldberger was a volunteer subject during the experimental period when it was desired to inject certain substances to test the transmissibility of the disease. The widow of Dr. Rudolph H. Von Ezdorf, yellow fever worker in the U. S. Public Health Service, receives a pension of $50 a month.

PLANS looking toward the erection of a monument to the memory of David Livingstone, missionary and explorer, have been started by the central council of the Federated Caledonian Society of South Africa. At their congress held in Bloemfontein, Orange Free State, last August it was decided to erect a bronze statue of Livingstone and to place it in the vicinity of the Victoria Falls, as this is considered his greatest discovery. A fund of from $60,000 to $80,000—$10,000 of which has been raised—is being sought from sympathizers of the project throughout the world.

THE Seismological Society of America will hold a meeting, arranged by its eastern section, at Fordham University, New York City, from April 30 to May 2.

THE fifth annual meeting of the Pennsylvania Academy of Science was recently held at the Pennsylvania State College under the presidency of Dr. Frank D. Kern. The academy now has a total membership of three hundred and fifty.

*Engineering and Industrial Chemistry* recently called attention to the establishment of a prize at Washington and Lee University by Dr. S. C. Lind, consisting of a membership in the American Chemical Society to be awarded to an undergraduate at that school. It now announces that the Pi Chapter of Alpha Chi Sigma at Syracuse University has voted to award a year's membership in the American Chemical Society to that chemistry student at Syracuse University who at the end of the first semester of his junior year is deemed the most representative man of his class.

A NEW field laboratory for investigations of tropical, subtropical and ornamental plant insects has been established at Sumner, Washington, by the bureau of entomology of the Department of Agriculture. The buildings have been erected by Pierce County, through the efforts of growers in the northwest. The laboratory plant consists of a group of buildings comprising the main laboratory, shop and storage shed, greenhouse and insectary. The main building contains laboratories and offices and space for storage. Approximately an acre of ground is available for field tests. Sumner is about thirty miles south of Seattle and ten miles southeast of Tacoma. The location is quite representative of the climatic conditions which prevail throughout western Washington and western Oregon, sections in which the different branches of the industries interested are most highly developed.

COMPREHENSIVE surveys of most desirable bird sanctuary sites will be made before executing the provisions of the Migratory Bird Act, according to a report made by W. C. Henderson, associate chief of the Bureau of Biological Survey. Federal bird refuges are needed in at least one hundred and twenty-five concentration areas, he states. The act will be carried out in fulfilling treaty obligations with Canada for protection of birds that spend part of their time in one country and part in the other. For the first time a national system of inviolate bird sanctuaries will be established.

DR. LAUGE KOCH, the Danish Arctic explorer, will undertake again a scientific expedition to Greenland. The cost of the expedition will be borne two thirds by Danes in England and the remaining third by the Carlsberg Fund. The expedition will start from Sabine Island, off the northeast coast of Greenland, working southward till it is slightly north of Scoresby Sound, all the operations taking place from the sea with the vessel *Godthaab* as a basis. In addition to the leader there will be six geologists, one botanist and two specialists in volcanic studies.

THE *U. S. Daily* reports that, operating in conjunction with a vessel of the Australian Navy, an amphibian plane of the Royal Australian Air Force has just completed a survey of the Great Barrier Reef, off northeastern Australia. The survey, which extended over one and a half years, is said to have demonstrated the utility of aircraft in expediting hydrographic work. The famed Great Barrier Reef, which extends for hundreds of miles parallel to the northeastern coast of Australia, contains many perils to navigation. During the past year and a half the

naval vessel and amphibian plane have been working together to increase the charted knowledge of the waters about the reef. The plane provided aerial mosaic pictures by taking vertical photographs from an altitude of eight thousand feet, which revealed the depth of the water beneath. The survey ship will proceed to sound all shallow waters revealed in the mosaic.

THE New York *Times* reports that the new vessel for Antarctic exploration being constructed in Glasgow by the British government will be the last word in efficiency for deep-sea sounding and biological and chemical investigation of southern waters. Not only will the vessel be capable of covering nine thousand miles without refueling, but echo-sounding gear will be installed and a special winch carrying five thousand fathoms of wire rope will enable working large nets at any depth. Three auxiliary machines will be carried for smaller nets and hydrological observations. There will also be large biological and chemical laboratories, a photographic room and a survey office. Six investigators will accompany the expedition. The officers and crew will number fifty. The vessel will be 232 feet long, steam propelled and be commissioned under the auspices of the Discovery Committee, which recently placed Captain Scott's old vessel *The Discovery* at the disposal of Sir Douglas Mawson and already has another vessel, *The William Scoresby,* working in the Antarctic.

SPACE on the fourth floor of the science building at the University of Southern California has been given over to experimental marine biology and survey work, with installation of running sea-water aquaria and other appropriate facilities, according to a report from Professor Francis M. Baldwin, in charge of marine biology work. Marine survey and invertebrate zoology are included in the summer session program, and space may be had by a limited number of independent investigators who have definite problems in hand, by application to Professor Baldwin. Two permanent tanks for sea-water and four auxiliary tanks for forcing the water around have been installed, and a reserve tank for the supply. The original supply of about 500 gallons came from four miles out in the Catalina Channel, and was dipped up in wooden buckets so that there would be no metal contact. As evaporation occurs, rejuvenation is effected by water added every week or ten days, and air is forced through to oxygenate it according to requirements stated on an automatic indicator.

THE will of the late Ogden Mills, of New York, who died on January 29, provides for the following bequests: The Home for Incurables, at 183d Street and Third Avenue, receives $500,000 under the will and an additional $500,000 under the codicil. Mr. Mills had been president of this institution and had given substantial sums to it during his lifetime. The American Museum of Natural History, to which he also contributed during his life, receives $100,000 under the will and an additional $400,000 under the codicil. The Mills Memorial Hospital at San Mateo, California, receives $200,000; Harvard College, $200,000; Grace Cathedral Corporation of San Francisco, $250,000; the Metropolitan Museum of Art of New York, $100,000; the New York Zoological Society, $50,000, and Phillips Exeter Academy of Exeter, N. H., $50,000. Mr. Mills was educated at Phillips Exeter and at Harvard.

DR. THOMAS BARBOUR, director of the Harvard University Museum, has left for Florida where he will join A. V. Armour for an extensive cruise, which will include Harvard biological and botanical foundations in southern latitudes. It is planned to proceed to Haiti, San Domingo, Porto Rico, then south through the West Indies to Trinidad, where the Imperial College of Tropical Agriculture will be visited. From there the course will be west through the Dutch Lesser Antilles to Venezuela, Colombia and Panama, stopping in the Panama Canal Zone for Professor Barbour's annual inspection of the Barro Colorado Island Tropical Research Station of the Institute for Research in Tropical America, of which he is chairman. On the way back a stop will be made at Tela, Honduras, where the expedition will visit the snake farm maintained by Harvard, the Antivenin Institute of America and the United Fruit Company. From there the expedition will proceed to Cuba to the Harvard Biological Laboratory and Botanical Garden at Soledad, Cienfuegos, Cuba. While cruising through the West Indies it is planned to visit the various tropical agricultural gardens and several of the smaller islands not touched by the regular trade routes, and, therefore, not visited by naturalists for many years. It is hoped to collect specimens of plants and seeds for introduction in the experimental stations at Summit, Canal Zone, Tela, Honduras and the Harvard Gardens in Cuba, and zoological specimens for the collections of the Museum of Comparative Zoology.

## UNIVERSITY AND EDUCATIONAL NOTES

THE alumni and directors of the University of Akron, Ohio, have raised $175,000 toward the build

ing fund of the proposed new university to be located three and a half miles from the center of the city.

THE department of sociology and anthropology at the University of Chicago has been dissolved and reconstituted as two separate departments. The department of sociology will be under the chairmanship of Dr. Ellsworth Faris, while the chairman for anthropology is Dr. Fay-Cooper Cole.

THE Grey University College at Bloemfontein, the chief town in the Orange Free State, has instituted a course leading to a degree in astronomy, the first in the Union. Professor Jan Paraskevopoulos, of the Harvard Observatory, and M. E. Jessup, of the University of Michigan, will conduct the course.

THE summer field course given at Grand Isle, Louisiana, under the auspices of the department of zoology of the Louisiana State University, will be repeated the coming summer from June 14 to July 24. The facilities of the laboratory are offered to research workers and others interested in marine biology during that season.

DR. RUSSELL M. WILDER, of the Mayo Clinic and Foundation, Rochester, Minnesota, has been appointed professor and chairman of the department of medicine at the University of Chicago. In the position of chairman of the department Dr. Wilder succeeds Dr. Franklin C. McLean, whose appointment as director of University Clinics was recently announced.

PROFESSOR KIRTLEY F. MATHER, of Harvard University, has been appointed exchange professor in geology at Tufts College.

DR. GEORGE T. HARGITT, of Syracuse University, and Dr. C. M. Child, of the University of Chicago, will serve next year as visiting professors at Duke University during the absence of Dr. A. S. Pearse, who has been granted a year and a half leave to aid in the establishment of the research work at Keio University, Tokyo, Japan.

PROFESSOR LINUS PAULING, at present at the California Institute of Technology, Pasadena, has been appointed lecturer in chemistry and physics in the University of California.

AT Harvard University, Sheldon fellowships enabling the recipient to travel for a year abroad have been awarded to Dr. Benjamin Kropp, instructor in zoology, and to Arthur Barton Brown, instructor in mathematics. Awards to students in physics have been made to James Holley Bartlett, Jr., and Clarence Melvin Zener; in botany to Walter Nicholas Bangham and Felipe Modesto Salvoza.

DR. ERIC D'ATH, pathologist at the Royal Prince Alfred Hospital, Sydney, has been appointed to the chair of pathology of the University of Otago, New Zealand.

DR. D. R. HARTREE has been appointed to the Beyer chair of applied mathematics in the University of Manchester. At present he holds a lectureship in mathematical physics at the Cavendish Laboratory, Cambridge.

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## DISCUSSION

### THE INTERACTION OF MATTER AND RADIATION

NOT many years ago we pictured a beam of light as a procession of waves, possessing wave-lengths and amplitudes. The latter, however, became electric vectors always at right angles to the direction of propagation. Recently we have come to look upon light as a flight of bundles of energy, every bundle having an energy proportional to the frequency or *vice versa*. And in the *explanation* of any phenomena of light now we use the idea of waves or electric vectors or quanta as we wish, ignoring the characteristics unnecessary to the *explanation*. In accounting for the pressure of radiation we may use any of the three characteristics as Maxwell, Larmor and Einstein have, in turn, shown. Or we may arrive at the result by purely thermodynamic reasoning, as did Boltzmann. In this point we are much better off than the physicists of one hundred years ago who could not accept the possibility of radiation pressure, yet if we go back two hundred years we find that Newton required light to have a pressure on the basis of his quasi-quantum, *i.e.*, corpuscular, view of its nature.

Most of the progress of the past twenty years has been based on the idea of the quantum and its action upon or production by electrons capable of motion from one energy state to another. The ejection of photoelectrons by light of definite frequency, the emission of light of definite frequency by electrons of definite kinetic energy, all the phenomena of resonance and ionization potentials, of X-rays, the spectral series as visioned by Bohr, the new quantum mechanics which is replacing the Bohr picture, in all of these the compact bundle of energy—the quantum—is the essential quality of light. Occasionally the electric vector is brought into service, for example, in accounting for the prevailing direction of ejection of the photoelectrons. That direction is, on the whole, along the electric vector of the effective light beam.

A recent theoretical contribution, that of Smekal in 1923, although derived purely on the basis of quanta, may have an interpretation on the basis of

waves. Smekal came to the conclusion that light passing through matter might find the atoms in such a condition that there would be an interaction, a coupling, of the two energy conditions with the result that radiation would be scattered from the atom with frequencies $n-p$, $n$, and $n+p$, where $n$ is the frequency of the radiation and $p$ that of the energy quantum involved in the resulting change of state of the atom. Now so far as frequencies are concerned this is analogous to the broadcasting by an atom of a carrier wave of frequency $n$, modulated by a frequency $p$ characteristic of the atom. It might be called the atomic voice frequency. His prediction was brilliantly confirmed by Raman and by numerous subsequent investigators. A variety of liquids and crystals show this effect; among the latter quartz is a conspicuous example. The outstanding fact in this phenomenon is the scattering of an increased as well as a decreased frequency, although it appears that the former may be filtered out or annulled in comparison with the latter. Or from another point of view it may be said that the probability of an atom taking up a quantum from the radiation is greater than the probability of the opposite transformation.

When we come to deal with the interaction of light on an isolated or nearly free electron no enhancing of the frequency can result. The phenomenon is relatively a simple one. We picture the radiation as a flight of bundles of energy, definitely related to the frequency, possessing momenta in keeping with their energy. When one of these quanta *strikes* an electron the latter acquires momentum and energy and the new (or old?) quantum rebounds or glances off always subject to the condition that the total momentum and energy remain constant. In every case in which there is a collision the rebounding or scattered quantum is decreased in energy and therefore in frequency. The greatest decrease is when the quantum rushes bull-headed at the electron and finds itself always thrown straight back, humbled, reduced in frequency, but perhaps consoling itself in the thought that it has sent the electron off at top speed. In this effect—the Compton effect—the lowering of frequency of the scattered radiation depends on the angle of scattering. It is the same for all free or nearly free electrons. In the Raman effect the change of frequency up or down does not depend on the angle of scattering but is dependent upon the energy states of the atoms.

Smekal does not tolerate the idea of waves in dealing with light. Quanta and frequencies are the only characteristics which he takes into account. And indeed in many of the new phenomena of light, waves with their electric and magnetic vectors are quite unnecessary. However, there is a predominant motion of the photoelectrons along the electric vector, and there is a corresponding preponderance of the recoil (free) electrons along the magnetic vector—though the latter observation has not as much evidence in its favor as one would wish.

A new phenomenon, however, comes to hand which will be *explained* by physicists of the older generation in terms of waves. Every amateur radio operator knows that if a continuous wave train of frequency $n$ is modulated or interrupted by a periodic device of frequency $p$ the frequencies resulting are $n+p$, $n$, and $n-p$. Now Rupp, of Göttingen, by means of a high frequency ($10^8-10^9$ per sec.) electrical oscillation and a Kerr cell has modulated the intensity of a *highly monochromatic* light beam and has found the frequencies indicated by theory. Here, however, on account of the square law of the Kerr cell the altered frequencies are $n+2p$ and $n-2p$. The new radiation is not scattered—it is direct.[1] Are there quantum interchanges as contemplated by Smekal? If so are they imposed on the atoms by the outside electrical frequency which is entirely under the control of the operator? No doubt this idea must be rejected. It seems clear that the ultimate reality in light is the energy quantum, frequency is merely a secondary, a derived property and wave-length is a convenient picture as it is now when we deal with the structure of the electron. I have in mind here the phase waves of the new electron which are regarded as waves in the q space and which have a velocity greater than the velocity of light; so related to the velocity of the electron that the slower it, the electron, moves the greater is the velocity of its phase waves—a rather difficult property to picture as a reality.

GORDON F. HULL

CAMBRIDGE, ENGLAND,
NOVEMBER 30, 1928

[1] There has just appeared in *Nature*, December 1, a letter by Bramley, of the Bartol Institute, giving the results of some experiments he has performed similar to that by Rupp. Using an iron arc and a Kerr water cell he obtains, for an electrical frequency of about $3\times10^8$, an increase of wave-length of 0.1 Å for two of the iron lines and no variation whatever for eight others. But the shift to be *expected is only* $3\times10^{-3}$ Å and can not possibly be detected except for extremely fine lines and can not be measured except by the use of the most precise methods. The half width of the green thallium line used by Rupp was 0.025 Å, and since the wave-length of the line was 5350.6 Å it would seem that he was working under very favorable conditions. However, Bramley's result might have been occasioned by high overtones in his electrical oscillations or, what amounts to the same thing, by Fourier components of his wave form. In any event, the result obtained is important and awaits interpretation.

## A FACTOR IN THE PROBLEM OF BIOLOGICAL PUBLICATIONS

DR. MAYNARD M. METCALF offers us in SCIENCE for March 8 some considerations on the problem of biological publication in America. Speaking for the entomological editors, as one of them, but only with a self-granted commission, I may say that the real drawback to extensive and expensive publication is the absence of adequate funds. I know of only one entomological society that has a fund for publications, the annual income of which may be between $500 and $600. At current rates, this allows for but 200 pages of matter per year; the rest of the funds must come from subscriptions. But entomological journals are many, and subscribers are few. This society may have an income from subscriptions of perhaps $700 more, which gives an additional 225 pages or so, with a *few* illustrations. Such a publication can not devote any one of its numbers to a one-hundred page monograph with twenty plates—this would cost them at least $500, nearly half of their total income.

The Brooklyn Entomological Society supports two publications, the *Bulletin* and *Entomologica Americana*, the former devoted to the shorter papers and the latter to monographs of one kind or another. The *Bulletin* deficit is reduced; but our income from subscriptions to *Entomologica Americana* is barely enough to publish 125 pages a year, with a few plates; but we do manage to publish about 240, without limiting our authors as to the number of plates or figures. We would like to grow bigger; and afford room for the monographs and adequate articles on various phases of entomology, but the support we receive limits us in our activities to a great degree. We have had to turn down meritorious work, because too extensive for our allotment of funds.

And that is the crux of the whole matter. These publications are unprofitable; they are run by societies at an actual loss; and, without the proper support, they are inhibited from growth.

It is too true that the fragmentary and preliminary discussions we publish are susceptible to later change and, naturally, are by no means final. But the remedy is in the hands of those interested. It may be urged that there are too many entomological journals. It is possible. But we must remember that entomology is a most extensive and active branch of biology; and the journals are far too few in comparison to the amount of first-class work that is being turned out. This lack naturally retards notably the progress of the science.

And further, there seems to be money from foundations of all kinds to finance almost anything but biological publications. An adequately financed publication in vertebrate zoology, for example, could readily publish many extensive papers suitably illustrated, which would discuss with finality matters in controversy. And this is peculiarly true of entomology. So small a sum as $10,000 per annum would make possible the publication of a number of definitive monographs on obscure groups by authoritative workers in these groups. Meantime, they see the labor of years lying fallow, and their real contributions to science perhaps lost. Their energy and their intellectual labor are made sterile by this lack of adequate funds.

The saddest thing about being an entomological editor is the necessity imposed upon one by cruel circumstance to reject all this meritorious work, because too extensive for the meager pocketbook.

J. R. DE LA TORRE-BUENO

## THE ALLEGED SCARCITY OF RESEARCH MEN

IN the review of the fifth New York meeting of the American Association for the Advancement of Science which recently appeared in SCIENCE[1] reference is made to a discussion of the difficulty of obtaining competent men for the direction of research work. I wonder if the men who took part in that discussion, and others who have voiced similar complaints, recognize and appreciate the fact that there are, in this country, many retired professional men, who have acquired a competence that renders them indifferent to salary considerations, and whose executive and administrative ability has been fully demonstrated by the success they have attained in their chosen fields of activity; and that some of these men would be very glad to become associated with research bureaus or institutions, if they were given the opportunity to carry on lines of investigation which are related to the work in which they have been engaged. Many of these men received special training in research, in their earlier years; but even if they did not, no one of experience can honestly contend that long-continued daily contact with the problems of engineering, for example, does not fully qualify men of ability either themselves to engage in what we are pleased to designate as "scientific inquiry," or intelligently to direct others in such work.

Is any effort being made to induce these retired professional men to accept positions in the various laboratories which have been, or are now being, established for the purpose of systematic research; or is

[1] February 1, 1929. pp. 107 to 131.

there any real attempt being made to even encourage them to consider such an association? As far as my professional observation goes the answer is *no*. On the contrary, suggestions, and in some cases offers, by such men to devote a whole or a part of their time to this work have been met with either a flat refusal or a veiled intimation that they had outlived their usefulness. And this in view of the well-recognized fact that many of the most notable discoveries and developments in the history of science have been made by men well past sixty.

What is the explanation of this attitude? Is it because younger men fear "the wisdom which lingers after knowledge comes"? Is it because the present directors of research laboratories or the presidents of our universities realize that men who have practical knowledge of the industrial arts and of the real problems which confront our manufacturers and business men might "nip in the bud" many of the silly and useless—or at least ill-advised—"investigations" which are now being carried on by various members of their staff? Is it because of the snobbish view—not always openly expressed, but very often existent—that no one who has not received a doctor's degree, and preferably from some *foreign* institution—is eligible to a seat with the "intellectuals"? Or is it because the scramble for reputations is more controlling than the search for truth?

Whatever the reason may be, let us, at least, have an end to these senseless complaints as to the scarcity of properly trained men "in whom the love of the work is greater than the desire for wealth and power" until some proper effort has been made to avail ourselves of the services of those who are able and anxious to round out a career of financial success and usefulness in the world by devoting the closing years of their lives to research.

F. L. O. WADSWORTH

PITTSBURGH, PENNSYLVANIA,
FEBRUARY 27, 1929

## CREPIS REUTERIANA AND ITS CHROMOSOMES

AN earlier note in this journal[1] called attention to the unfortunate confusion which had arisen concerning the identity and chromosome number of *Crepis reuteriana* Boiss. This species has now been obtained in living condition from three different localities in the Mediterranean region, and the chromosomes of two of these accessions have been examined and found to be closely similar. The number is n = 4, and the chromosomes are much larger than those of *C. capillaris*. Unlike *C. capillaris*, this species is a perennial. It is much more closely related to *C. pulchra* and *C. palaestina* than to other annual species.

E. B. BABCOCK

BERKELEY, CALIF.,
DECEMBER 6, 1928

LILLIAN HOLLINGSHEAD

## THRIPS AS CARRIERS OF FIG-DECAYING ORGANISMS

DURING the past decade the fig growers of California have suffered rapidly increasing losses due to various rots, decays and fermentations of their product, caused by cryptogamic organisms carried into the cavities of the figs by various insects. Caldis[1] shows that *Fusarium moniliforme fici* Cald., which causes a rot (endosepsis) of caprified figs, is transmitted from the wild to the edible fig by the caprifying insect *Blastophaga psenes* L. Phillips; Smith and Smith[2] list a number of insects which feed upon or enter the maturing fruit of all varieties of figs. *Carpophilus hemipterus* L. and *Drosophila ampelophila* Loew. are by these authors and other investigators considered to be the main carriers of the organisms causing two of the principal fig diseases, smut (*Aspergillus niger* Van T.), and souring, under which name is included all kinds of rots and fermentations exclusive of smut and endosepsis. *Notoxus constrictus* Cas., *Blapstinus fuliginosus* Cas., *Cnemeplatis sericea* Horn, and a mite, *Eriophyes fici* Ew., are considered unimportant as disease carriers by the authors. It has been the general consensus of opinion that where caprification is not practiced no insects enter the figs while they are green and hard. In May, 1928, the writer collected several thousand uncaprified, hard, green figs of four varieties: Calimyrna, Adriatic, Kadota and Mission, from various parts of California. These figs were cut into halves and examined with a hand lens for evidence of insect invasion, mutilated and discolored floral parts, insect excreta or the insects themselves. Slightly in excess of 20 per cent. of the figs examined were found to be infested with thrips, specimens of which were identified by Mr. Dudley Moulton, of San Francisco, as *Thrips tabaci* Lind. and *Frankliniella sp.*, probably *F. californica* Moul. The interior of two hundred of the figs showing evidence of insect invasion, and ten showing no such evidence, were cultured individually on nutrient media to determine their cryptogamic flora. Each of the two hundred thrips-infested figs yielded one or more of the following organisms: various species of Bacteria, *Rhizopus spp.*, *Aspergillus spp.*, *Penicillium spp.*, *Fusarium spp.*, *Verticillium spp.*, *Spicaria sp.*, *Hormodendrum spp.*, and a number of yeasts. The ten figs showing no evidence of insect invasion yielded

1 E. B. Babcock, "Species of Crepis," SCIENCE, 70: 175–6, no. 1547.

1 *Hilgardia*, 2: 287–324, 1927.

2 Cal. Agr. Exp. Sta. Bull., 387: 1–38, 1925.

no cryptogamic flora in culture. The above results show that when green, hard figs are entered by thrips they become inoculated with organisms capable of producing various decays and fermentations in the ripening fruit. Though the 1928 season was especially favorable for thrips the comparatively high percentage of green, hard figs found infested would indicate that infection from this source alone is sufficiently great to cause the growers considerable loss. It is also possible that the early start of decay and fermentation in thrips-infested figs, giving rise to odors very attractive to *C. hemipterus* and *D. ampelophila*, is partly responsible for the appearance of these insects in the orchards at the time when figs begin to mature. This and other phases of fig diseases are being further studied by the author.

H. N. HANSEN

LABORATORY OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA

## GALBA BULIMOIDES LEA AN INTERMEDIATE HOST OF FASCIOLA HEPATICA IN OREGON

IN studies of the liver-fluke problem in Oregon a survey of the *Lymnaeidae* of the state was made. Of the five species[1] collected *Galba bulimoides* Lea was the only one which was found in every fluke-infested pasture which was examined.

Five different cercariae were observed in this species. One of these, an unarmed type, was obtained repeatedly from specimens of *G. bulimoides* collected in a fluke-infested pasture. Studies of this cercaria revealed that it agreed both morphologically and physiologically with the descriptions and photographs of the cercaria of *Fasciola hepatica*. Daughter rediae were not found. Mother rediae, obtained by crushing snails, agreed with the descriptions of redia of liver flukes. Furthermore, these rediae and cercariae were apparently identical with rediae and cercariae obtained from live specimens of *Fasciola hepatica* infested *Lymnea truncatula* Müller received from Dr. R. F. Montgomerie, of University College of North Wales, Bangor, Wales.

It was proved that these were forms of *Fasciola hepatica* by feeding encysted cercariae to guinea pigs and recovering typical liver flukes from their livers upon autopsy.

J. N. SHAW
B. T. SIMMS

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CORVALLIS, OREGON

[1] Identifications of mollusks were by Drs. H. A. Pilsbry, Paul Bartsch, W. B. Marshall, G. Dallas Hanna, A. W. Hanham and J. R. C. B. Tomlin.

## THE RADIOACTIVITY OF LIGHT ELEMENTS

THE statements made in the past and repeated recently (*Lind-Chemical Reviews*, 5 (1928): 366) that no element of atomic weight less than 210 has been found to exhibit radioactivity except potassium and rubidium suggest that these exceptions may eventually be ruled out. The unknown element number 87 coming just before radium in the periodic system would probably be radioactive. This element being a member of the alkali metal family should occur with rubidium or potassium. The suggestion then may perhaps be made that whatever radioactivity is shown by specimens of potassium or rubidium is due to the presence of traces of the heavy element number 87, and that the discovery of this element should come about through the examination of radioactive rubidium or potassium.

JAMES M. HENDEL

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NEW YORK CITY

## RAMAN SCATTERING FROM HCl LIQUID

WE have observed the Raman effect with pure hydrogen chloride liquid, at $-100°$ C., using a mercury arc and Hilger E62 spectrograph. A scattered line whose center is at 4560 A. U. persists with the incident light filtered so as to give only the 4047 line strongly, indicating an absorption band at 3.60 $\mu$ for HCl liquid. The modified line is several times broader than the unmodified line, and is more diffuse at its long than at its short-wave edge. Modified scattering of the 3.6 $\mu$ band of HCl gas was reported recently by R. W. Wood (*Nature*, February 2, 1929).

Our resolving power was insufficient for the separation of lines as close together as the rotational lines of HCl gas, but the work is being continued with better resolution. The infra-red spectrum of HCl liquid is also being measured.

E. O. SALANT,
*National Research Fellow*,
A. SANDOW

DEPARTMENT OF PHYSICS,
WASHINGTON SQUARE COLLEGE,
NEW YORK UNIVERSITY,
MARCH 22, 1929

## PROFESSOR HUNTINGTON'S METHOD IN CONTROVERSY

IN his latest contribution to the discussion on apportionment (SCIENCE, March 8, page 272), Professor Huntington brands as false my statement "that a certain series quotients 'would sum up to 435.'"

I wrote "the whole series would sum to 435," which is true but possibly ambiguous. By inserting the

words "of quotients" Professor Huntington has given my meaning a twist which I never intended. The whole series "of representatives" would sum to 435.

To test how much ground there is in the passage for the misinterpretation I handed copies of my letter to a class of 30 undergraduates, said that there was an ambiguity in one sentence which I identified, and left them to decide what it was, and how they would interpret it. Three fourths of the class thought the meaning was "series of representatives," one fourth thought it was "series of quotients." None of them knew about the interpretation Professor Huntington had put on my words, or why I had asked them the question.

It is hard to understand how a scholar of the position of Professor Huntington could have given my words the meaning he did, and have failed to see that they would bear another meaning which would make them true. It is the harder because after his study of apportionment he must know that in the tables submitted to Congress it has been the practice to print the two series in adjoining columns and to give the sum of the representatives but not of the quotients.

Hitherto I have not answered Professor Huntington's personal attacks but this case is so clear and typical that I have made an exception. *Ab uno disce omnes.*

WALTER F. WILLCOX

CORNELL UNIVERSITY

## QUOTATIONS

### INDUSTRIES AND RESEARCH

THERE is one striking and rather disturbing feature of the position in this country with regard to cooperative industrial research. It is specially mentioned in the recently issued report of the Department of Scientific and Industrial Research, and it has been painfully obvious ever since the government scheme for assisting cooperative industrial research came into existence nearly ten years ago. This is the great difficulty of obtaining from the various industries which have set up industrial research associations, with the aid of the government grant, sufficient funds in some cases to earn the government grant and in others even to keep the research association going at all.

The department has hitherto taken a very lenient view of this reluctance on the part of industries to provide funds, but with the approaching completion of ten years of government assistance it is felt that research associations should be self-supporting. Some outspoken comments are made on this matter in the report.

When the scheme was first started cooperative industrial research was an experiment in this country, the result of which no one could accurately foresee, and in the circumstances it was felt that it was justifiable for the state to bear half the cost for a period of five years. When that period came to an end it was agreed that a continuance of state aid was desirable for a further period of five years in view of the special difficulties of British industry. This second period having almost expired, the request has been made to the Department of Scientific and Industrial Research that the state should continue to bear half the cost where industrial research associations have been formed. That proposal has been rejected definitely by the department on the ground that the value of cooperative industrial research has been established, and therefore the industrial research associations, having had ten years' state assistance, should be self-supporting. It is proposed that when the existing contracts come to an end each association shall be considered on its merits and a subscription income fixed which it will be necessary for the association to obtain from other sources before it is eligible for any grant from the department. Only as regards funds obtained in excess of this fixed amount will the department be prepared to make a grant. In other words, this is a clear hint to the industries of the country that they must adequately finance their own research associations, and on general principles it is a sound policy at the present stage of development.

Those who have come in close contact with this work can not but feel sympathy for the manner in which the councils and technical directors of the industrial research associations are always begging the members of their respective industries for additional financial support. At least one such association has gone out of existence because the industry has been unable to raise the necessary funds to earn even the generous grant from the state under the original scheme. The plight of some of the others is such as to cause astonishment. There are at present nineteen such industrial research associations, and it is hard to find a cause why sufficient financial support to enable them to be self-supporting after having had a run of nearly ten years is not forthcoming. Investigation work is having to be curtailed or carried out on a much smaller scale than is desirable for the obtaining of the best results. These associations carry out work of a fundamental character which is inevitably of outstanding financial value to the industries, and in seeking to ascertain the reason for the comparative poverty of our industrial research associations, the reflection is inevitable that all our leading industrial organizations have their own research departments in which a good deal of fundamental, as well as immediately practically valuable, research is being carried out. Whether that is the cause can not be stated definitely; indeed,

offhand, it would appear not to be a reason for failing to support the cooperative research organization.

The difficulties are well shown in the promotion in Parliament of the Rubber Industry Bill, which had for its object the imposition of a statutory levy on all imported (and retained) rubber for the purpose of financing cooperative research. That was opposed by some of the manufacturers, although it was warmly advocated by the majority of the trade. The bill, however, could not be presented for third reading last session owing to lack of time, and it, therefore, failed.

An interesting sidelight on the attitude in some quarters towards cooperative research is given in the report of the department. It is stated that a prominent firm which had been a strong supporter of its research association had a large overdraft at the bank, and the bank, as one condition of arranging the overdraft, insisted that the subscription to the industrial research association should be withdrawn on the ground that it was an unnecessary expenditure.—*Correspondent of the London Times.*

## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### THE USE OF "DRY ICE" OR SOLID CARBON DIOXIDE AS A LABORATORY REFRIGERANT

"DRY ICE" is a trade name for solid carbon dioxide. Carbon dioxide is a gas at ordinary temperature, but solidifies at a temperature of −73° C. or −100° F. Solid carbon dioxide has been known for a long time, mainly as a laboratory curiosity, being easily prepared from liquid carbon dioxide by tying a piece of cloth over the outlet of a steel tank of the latter and allowing some of the contents to escape. As the liquid evaporates it takes up a large amount of heat and so part of it is cooled down to the solidification point. This forms the $CO_2$ "snow" as it is called, since it resembles real snow very much.

During the last few years solid $CO_2$, or Dry Ice, has assumed commercial importance as a refrigerant, particularly for perishable goods in transit, being used in place of ice from water. It is manufactured for this purpose on a large scale, recourse being had to not only cooling but high pressure in making it. Its advantages over "regular" or ordinary ice are easily perceived. It is much colder and thus a given weight will be more effective, it lasts longer, and on melting disappears as a gas into the air, leaving no water, as is the case with ordinary ice.

It is prepared in ten-inch cubes weighing forty pounds each. In lots of forty to two hundred pounds it costs ten cents per pound. In lots of two hundred pounds or more it costs five cents per pound.

During the past year in connection with hardiness studies the writer has had occasion to attempt some freezing tests on apple twigs as a check on other methods of determining hardiness. That is, it was desired to freeze different samples of twigs from different varieties of apples during the dormant period, holding them at varying temperatures from −5° C. down to −40° C., perhaps, and thus to determine their killing point. Liquid $CO_2$ in steel tanks was first tried. In this case the $CO_2$ was allowed to expand in a copper expansion coil surrounded by an ether bath. The excised twigs were placed in sealed glass bottles in the ether. This seemed to require too much $CO_2$ and was therefore abandoned in favor of solid $CO_2$. This proved very satisfactory, as it was cheaper, the work could be done faster and the method is simple.

Pint-size thermos bottles were used as containers, mainly because they were available. Quart size would perhaps be better, as larger sizes of twigs could then be used. They were about two thirds filled with ether and stoppered loosely with one-hole rubber stoppers, through each of which was thrust a thermometer so that its lower end dipped into the ether. The twigs were cut in about six-inch lengths and placed in sealed test-tubes, and these placed in the thermos bottles, two test-tubes in each. The temperature was lowered gradually by dropping into the ether small pieces of Dry Ice, a little at a time. The fragments sink to the bottom and volatilize rapidly, thus causing a violent bubbling which aids in maintaining the temperature of the bath the same in all parts of the container. After the desired point was reached it could be held by dropping in another small fragment whenever the temperature started to rise slightly. In cases where a large number of samples of twigs were to be frozen, a gallon-size thermos jug, such as used by campers, was used as a container. Thus the results for several varieties would be exactly comparable, all being held at the same temperature for any given series.

Care must be taken in handling the Dry Ice as it burns the hands when held even for an instant. Blocks of a pound or more were cut off with an ordinary wood saw. These in turn could be broken into smaller fragments with a knife or cold chisel. A supply of small pieces for cooling down the ether was kept in a thermos bottle.

After the twigs had been kept at the desired temperature for a given length of time, one hour in these experiments, they were taken out and placed in small, wide-mouthed bottles with their lower ends in water. They were then allowed to bud out at room temperature, those failing to do so being regarded as killed.

Over a range of several different temperatures marked differences in varieties could be noted.

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## THE USE OF SOLID CARBON DIOXIDE IN MAKING FREEZING-POINT DETERMINATIONS WITH PLANT JUICES

DUNN[1] has recently employed "Dry Ice" as a refrigerant in subjecting tissues of apple stems to freezing temperatures.

The ease with which this material can be handled and the ease with which low temperatures can be obtained and maintained caused the writer to test out its use as a refrigerant in determining the freezing-point depression of plant juices.

Although others may possibly have employed Dry Ice for this purpose, it seems to the writer that knowledge of this method should receive more publicity. Because of the ease of manipulation and the cleanliness and rapidity of the method, it seems as though its use would be of value to workers in the plant sciences.

In this method an ether bath surrounds the air jacket of the usual Beckman freezing-point apparatus. The temperature of the bath is regulated by adding to it pieces of Dry Ice (solid $CO_2$) until the desired temperature is reached. When the pieces of Dry Ice drop into the ether they sink, causing at the same time violent bubbling of the liquid, while the temperature of the bath becomes lower. The bubbling causes the temperature of the bath to become uniform throughout, dispensing thus with stirring.

The air-jacket may be filled with ether or alcohol if desired. The ether bath should be in a cylindrical container, tall enough to accommodate the air-jacket and its contents and the auxiliary thermometer. The container may be of metal, enamelware or glass, and should have a capacity preferably of two to two and one half liters, and tall enough to accommodate the freezing tube.

The desired temperature of the bath may be maintained during an experiment by adding small pieces of solid $CO_2$ whenever there is a tendency for the temperature of the bath to rise. The apparatus should be placed in sawdust or some other insulating material.

The advantages of using ether for a bath lie in the following points: (1) Ordinary ether is cheap. (2) The freezing-point of ether is very low. (3) Ether is volatile, leaving the apparatus clean after its use. (4) In other liquids that are volatile and do not adhere to the parts of the apparatus in contact with them, difficulty is obtained in lowering the temperature of the bath if water is present. For this reason alcohol has been discarded as a bath. In alcohol the pieces of $CO_2$ become coated with ice which retards or stops the volatilization of the $CO_2$.

It is apparent that this method excels as cooling is produced by drawing air through the ether bath causing rapid evaporation therein because of the more rapid lowering of the temperature.

The advantages of this method over methods where a salt-ice mixture is used are the following: (1) The temperature of the cooling mixture is more easily controlled. (2) The material is cleaner and easier to handle. (3) The ether in the bath may be used over and over again. (4) The temperature of the ether bath can be lowered more rapidly and accurately.

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[1] Stuart Dunn, "The Use of 'Dry-Ice' or Solid Carbon Dioxide as a Laboratory Refrigerant," SCIENCE, March 29, 1929.

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# SPECIAL ARTICLES

## SERIES IN THE ARC SPECTRUM OF BROMINE[1]

RECENTLY we have photographed the spectrum of bromine as emitted by a Geissler tube, from the ultra-violet to beyond 9300A in the near infra-red. The type of spectrum obtained depends both on the pressure of the gas within the tube and the character of the exciting discharge. When the gas at low pressure is activated by an uncondensed discharge from a high-voltage transformer the spectrum observed is predominantly that of the neutral atom, the arc spectrum.

With the new wave-length data and the wave-lengths observed by Turner[2] in the Schumann region, we have succeeded in working out the structure of the arc spectrum, Br I. The theoretical structure of the spectrum is similar to that of Cl I which we described in our note to SCIENCE for October 12, 1928. Turner's lines represent the combination of the lowest term $s^2p^4 \cdot 4p\ ^2P$ with the higher $^2P$ and $^4P$ terms coming from the electron configuration $s^2p^4 \cdot 5s$. These terms, in turn, combine with still higher terms coming from $s^2p^4 \cdot 5p$ and $s^2p^4 \cdot 6p$ to give the prominent arc lines observed in the infra-red and in the green and blue.

For the lines observed by Turner, we give the following classification.

The lines from the $5p$ and $6p$ electrons are in Rydberg sequence. We therefore use them in calculating

[1] Publication approved by the director of the Bureau of Standards, of the U. S. Department of Commerce.

[2] *Physical Review*, 27: 400. 1926.

| λ | Int. | Term combination |
|---|---|---|
| 1576.5 | 6 | $^2P_2 - {}^4P_3$ |
| 1540.8 | 6 | $^2P_2 - {}^4P_2$ |
| 1488.6 | 8 | $^2P_2 - {}^4P_1$ |
| 1633.6 | 10 | $^2P_1 - {}^4P_2$ |
| 1575.0 | 9 | $^2P_1 - {}^4P_1$ |
| 1449.9 | 3 | $^2P_2 - {}^2P_1$ |
| 1582.4 | 8 | $^2P_1 - {}^2P_2$ |
| 1531.9 | 7 | $^2P_1 - {}^2P_1$ |

the ionization potential of approximately 12.2 volts for the neutral atom. This value is checked by interpolation from the known ionization potentials of Ga, Ge and Kr.

Both Kimura[3] and Hori[4] have published observations of the complex structure of Br lines. We have used the Fabry-Perot interferometer in observing the Br spectrum and we confirm their findings as to the fine structure of numerous lines.

The details of this investigation will appear in an early number of the Bureau of Standards *Journal of Research*.

T. L. DEBRUIN
C. C. KIESS

BUREAU OF STANDARDS

## ON THE BIOLOGICAL EFFECTS OF X-RAYS

THE object of this note is to record briefly the results of experiments upon *Saprolegnia ferax* carried out during the summers of 1925 and 1926 at Woods Hole. It was to be expected that with modern radiation apparatus and a knowledge of the technique as applied to *Drosophila, Saprolegnia* with its extremely sensitive behavior toward chemical changes and its various modes of reproduction would provide changes under the action of X-rays which could be treated statistically. Except for a possible stimulus to nuclear division in the mycelium under the influence of X-rays, extensive experimentation on the rate of growth in culture media, on the formation and liberation of zoospores, the formation of oogonia and oospores, and the movement of protoplasm, failed to produce any results which could be attributed to the action of X-rays. The amount of radiation was enormously greater than had been employed with *Drosophila*. A dosage of 50,000 volts at 2.5 m.a. for twenty minutes with a standard Coolidge tube, and the material at 12 cm from the tungsten target (in our method of recording represented by 32D),[1] had been sufficient to cause complete sterility in *Drosophila* for two days and partial sterility for ten days. Applications as high as 75,000 volts at 10 m.a. for forty-five minutes at a similar distance from the tube failed to produce any results in *Saprolegnia*. The material radiated was exposed in water in small petrie dishes, duplicate material being kept as a control. The entire life cycle of *Saprolegnia* may be carried out in from two to three days. These experiments were so conducted that samples of the radiated material could be removed for study or staining without disturbing the remaining material. It was desirable to keep a large amount of material permanently, and after experimentation with many stains it was found that gentian violet for eighteen to twenty-four hours, destained by xylol, would show chromosomes in the mycelium and the oogonia without recourse to sectioning. The chromosomes, however, are minute.

As regards *Drosophila*, the writer does not presume to say that mutations can not possibly be induced by X-rays, but a series of carefully planned and extensive experiments carried out in 1922–1924 by the writer with the cooperation of Dr. Mavor, having as one of the primary ideas the possible production of mutations by X-rays, failed entirely to produce any physical mutations which could be detected. In these experiments, with special reference to three characters of the second chromosome, black, purple and curved, under various dosages of X-rays, some 120,000 individuals were individually examined in four repeated experiments, one half the number being controls. In no case could mutations be detected in greater numbers than appeared normally in the stock. Crossovers from the "recovery period," *i.e.*, the period of greatest percentage of crossover after X-ray treatment, were bred in numerous auxiliary experiments; in one of these the increased crossover percentage was clearly demonstrated as not inherited,[2] and there was no sign of mutations.

From these experiments the writer believes that X-rays tend to show the extraordinary resistance of the germ-plasm to change by experimental means. Either the organism is killed, *i.e.*, by lethal rays during maturation divisions in the egg, resulting in complete or partial sterility; or the changes in percentage of crossing-over which accompany the recovery period disappear in the succeeding generation.

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## CONTROL OF THE COTTON BOLL WEEVIL BY INSECT ENEMIES

PRIOR to the use of poisons for the control of the cotton boll weevil (*Anthonomus grandis* Boh.), the attention of many entomologists interested in the

[3] Memoirs, College of Science, Kyoto, 4: 139. 1920.
[4] Memoirs, College of Science, Kyoto, 9: 307. 1926.
[1] J. W. Mavor and H. K. Svenson, *Genetics*, 9: 588–608 (1924), and previous papers.
[2] *Am. Nat.*, 58: 311–315. 1924.

control of this insect pest became directed towards an intensive study of the weevil's insect enemies.[1] During the past fifteen years, however, but little recognition has been given this phase of natural control of the weevil. On the other hand, distinct advancement in the cultural methods of boll weevil control is generally recognized, and consequently a larger quantity of more suitable fertilizer is annually used for growing better and earlier varieties of cotton.

Since the heavy weevil damage in 1923, there appears to be a lessening of the general damage to cotton which is attributed directly to the boll weevil. Severe local infestations, however, have occurred throughout the cotton belt. Such occurrences are similar to the experiences of entomologists working with other insect pests controlled wholly or in part by their insect enemies. Furthermore, it must be remembered that the boll weevil has been in the United States for at least thirty-four years, becoming established in the entire cotton belt by 1922. Consequently it seems probable that the importance of insect enemy control might be greatly increasing.

It is a significant fact that the boll weevil has some fifty-five insect enemies, including parasites and predators; but of still greater significance is the fact that these enemies are all native insects which were present in the cotton belt before the weevil arrived. Stated more in detail, the boll weevil is attacked by twenty-nine native species of parasites, twenty native species of predators which attack the immature stages and six native species of predators which attack the adults. These particular insects have a large number of native hosts (fifty-two other weevils which in turn attack ninety-one other species of plants), and are to be found in great abundance in the neighborhood of cotton fields.

A number of entomologists have determined that the life-cycle development of the boll weevil parasites is as rapid as that of the boll weevil. This fact, in addition to the early occurrence of other hosts of the parasites, tends to insure a timely presence of numerous parasites to combat the boll weevil. It is not astonishing, therefore, that there should be many areas in the cotton belt where boll weevil damage appears to be growing less severe.

During the past six years the writer has repeatedly observed natural control of rather severe initial boll weevil infestations. Out of these six years only three were climatically unfavorable for the weevil, hence the writer's attention became directed to the insect enemies of the weevil. The accompanying table was compiled from a series of collections of weevil-punctured cotton squares which were forwarded to the insectary at Gainesville, Florida, where the weevils and parasites were hatched.

| Locality | Date collected 1926 | Punctured squares examined | Boll weevils hatched | Parasites hatched | Per cent. hatched boll weevils | Per cent. hatched parasites |
|---|---|---|---|---|---|---|
| Campbellton, Fla. | July 30 | 190 | 119 | 1 | 62.63 | 0.53 |
| Americus, Ga. | July 7 | 765 | 381 | 7 | 49.80 | 0.92 |
| Greenville, Fla. | August 1 | 405 | 190 | 37 | 46.91 | 9.14 |
| La Crosse, Fla. | July 18 | 540 | 207 | 35 | 38.33 | 6.48 |
| Thomasville, Ga. | July 5 | 450 | 170 | 0 | 37.78 | 0 |
| Bonifay, Fla. | August 1 | 390 | 135 | 5 | 34.62 | 1.28 |
| 12 Mi. S. of Dothan, Ala. | July 30 | 413 | 137 | 80 | 33.17 | 19.37 |
| Alachua, Fla. | July 18 | 900 | 282 | 58 | 31.33 | 6.44 |
| 6 Mi. S. of Greenville, Fla. | August 1 | 402 | 102 | 3 | 25.37 | 0.75 |
| 4 Mi. W. of Campbellton, Fla. | July 30 | 348 | 87 | 16 | 25.00 | 4.60 |
| Hurtsboro, Ala. | July 9 | 1100 | 266 | 18 | 24.18 | 1.64 |
| 4 Mi. N. of Madison, Fla. | July 29 | 376 | 75 | 18 | 19.95 | 4.79 |
| Dothan, Ala. | July 30 | 316 | 56 | 9 | 17.72 | 2.85 |
| Columbus, Ga. | July 8 | 900 | 150 | 8 | 16.67 | 0.89 |
| 5 Mi. N. of Madison, Fla. | July 29 | 574 | 83 | 24 | 14.46 | 4.18 |
| 6 Mi. S.E. of Madison, Fla. | July 29 | 382 | 13 | 68 | 3.40 | 17.80 |

Sixteen localities were examined and in but three of these, Campbellton, Florida, and Americus and Thomasville, Georgia, was weevil poisoning carried on. A fair yield of cotton was obtained in all sixteen localities.

It is the opinion of the writer that a more extensive study of the natural enemies of the boll weevil will indicate that they are generally becoming more important as a limiting factor in boll weevil damage.

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[1] W. Dwight Pierce, "The Insect Enemies of the Cotton Boll Weevil," Bul. 100. Bureau of Entomology, U. S. D. A. 1912.